3-E
FLOW MANAGEMENT AND SAFETY RELIEF POINT

FINAL ENVIRONMENTAL IMPACT STATEMENT

Brightwater Regional Wastewater Treatment System

APPENDICES

Final

Appendix 3-E
Flow Management and Safety Relief Point

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Introduction

King County has prepared a Draft Environmental Impact Statement (Draft EIS) and Final Environmental Impact Statement (Final EIS) on the Brightwater Regional Wastewater Treatment System. The Final EIS is intended to provide decision-makers, regulatory agencies and the public with information regarding the probable significant adverse impacts of the Brightwater proposal and identify alternatives and reasonable mitigation measures.

King County Executive Ron Sims has identified a preferred alternative, which is outlined in the Final EIS. This preferred alternative is for public information only, and is not intended in any way to prejudge the County's final decision, which will be made following the issuance of the Final EIS with accompanying technical appendices, comments on the Draft EIS and responses from King County, and additional supporting information. After issuance of the Final EIS, the King County Executive will select final locations for a treatment plant, marine outfall and associated conveyances.

The County Executive authorized the preparation of a set of Technical Reports, in support of the Final EIS. These reports represent a substantial volume of additional investigation on the identified Brightwater alternatives, as appropriate, to identify probable significant adverse environmental impacts as required by the State Environmental Policy Act (SEPA). The collection of pertinent information and evaluation of impacts and mitigation measures on the Brightwater proposal is an ongoing process. The Final EIS incorporates this updated information and additional analysis of the probable significant adverse environmental impacts of the Brightwater alternatives, along with identification of reasonable mitigation measures. Additional evaluation will continue as part of meeting federal, state and local permitting requirements.

Thus, the readers of this Technical Report should take into account the preliminary nature of the data contained herein, as well as the fact that new information relating to Brightwater may become available as the permit process gets underway. It is released at this time as part of King County's commitment to share information with the public as it is being developed.

Executive Summary

A primary purpose of the proposed Brightwater System is to add regional wastewater conveyance and treatment capacity to reduce the probability of County regional-system-caused sanitary system overflows (SSOs) into local systems, homes, and private property. Without the added capacity of the Brightwater System and as the population of the service area in King and Snohomish Counties continues to increase over time, SSOs in the County's system will gradually occur on a more frequent basis. The proposed Brightwater System will serve to reduce the frequency of these County regional-system-caused SSOs to only one event approximately every 75 years or longer.

In spite of its very limited potential use (approximately once every 75 years), King County is proposing a safety relief point as a part of the Brightwater System. The safety relief point in the Kenmore area would prevent these unusual combinations of high flows and/or power and equipment failures within the King County Brightwater System from causing SSOs in homes and private property. The safety relief point would also provide a known location in the County's Brightwater Conveyance System where an unusual system emergency SSO could be monitored and mitigated.

The King County Brightwater Conveyance System will be sized to accommodate flows up to 170 mgd (million gallons per day), which is the estimated flow during a 20-year peak flow event in 2050. During emergency flow conditions, when peak flows exceed either the capacity of the treatment plant or conveyance system, King County can implement one or more of the following flow management strategies to reduce the probability of SSOs:

- Divert wastewater to King County's West Point and South Treatment Plants through the Kenmore Interceptor Section 2 and Eastside Interceptor, respectively.

- Divert excess flows into the 4-million gallon (MG) Logboom Park Storage Facility and 6-MG North Creek Storage Facility. The stored wastewater would then be returned to the conveyance system once peak flows have subsided and conveyance capacity is available.

- Implement controlled surcharging of the existing Bothell-Woodinville Interceptor (for 2 MG of additional storage) and the new influent tunnel. The volume of storage available in the influent tunnel would be a function of various tunnel parameters, such as tunnel diameter, slope, and design capacity.

The total volume of extra storage varies between conveyance system alternatives. Flow management will likely involve combinations of all three of these strategies.

The implementation of flow management strategies will help to reduce the probability of SSOs in the conveyance system or at the treatment plant discharging to the Sammamish River or Lake Washington. During extreme flow events or operational emergencies, where the use of flow management procedures does not reduce the wastewater flow rates to manageable levels, the system design goals are such that wastewater SSOs will occur into selected natural receiving waters through a safety relief point rather than causing backups into local systems.

Two analyses were performed to evaluate the proposed safety relief point: one to estimate the probability that a discharge would occur at the facility, and a second to characterize the potential impacts of such a discharge. A probability computer model incorporated parameters such as mechanical reliability, reliability of influent pump station electrical power sources, influent tunnel design parameters, flow event recurrence intervals, and storage volume in existing King County facilities. The model used two sets of flow and storage parameters: (1) projected year 2030 Phase I peak flow and storage volume parameters, and (2) projected year 2050 Phase II peak flow and storage volumes. The results of the SSO discharge probability analysis are shown in Chart 1. Given an available storage volume in the influent tunnel of 11.3 MG, the estimated safety relief point discharge recurrence frequency would be greater than 1-in-100 years for Phase I of the proposed Brightwater System and 1-in-75 years for Phase II.

The discharge impact characterization was conducted using a King County hydraulic model of the Sammamish River and the water quality data for untreated wastewater and the Sammamish River. The HEC-2 model indicated that the discharge plume from the Kenmore safety relief point would most likely extend the entire width and depth of the Sammamish River and extend approximately 3,800 feet into Lake Washington. Surface water quality criteria would not be met at the edge of the plume for ammonia, copper, lead, mercury, and turbidity if the Sammamish River received such an SSO event.

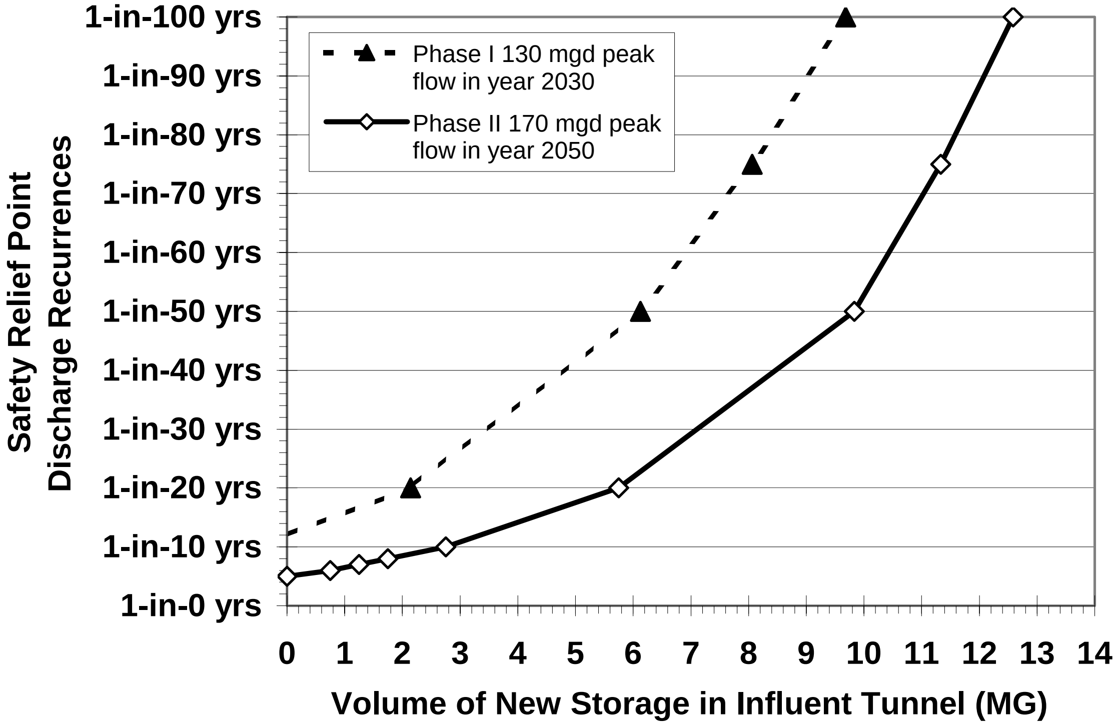


Chart 1. New Storage Volume Required to Prevent Safety Relief Discharge for Six Hours

Brightwater Flow Management

The Brightwater Treatment System will be designed to accommodate flows up to a 20-year peak flow event. However, peak flow and operational conditions could develop that result in unusual flow conditions that exceed the capacity of sections of the conveyance system. The following sections discuss situations that can generate these flow conditions and the emergency flow management strategies that King County could implement to manage the flows.

Existing King County Conveyance Facilities

Approximately 55 miles of pipelines, six pump stations, one regulator station, and two storage facilities are within the service area of the proposed Brightwater Treatment Plant. Currently, during the summer months, all wastewater conveyed to the King County system from southern Snohomish County flows southwards to King County interceptors in the Kenmore area. Wastewater collected from the north end of Lake Sammamish flows north and west to the same area. The existing Kenmore Pump Station then pumps this wastewater through the Kenmore Interceptor Section 2 ("Kenmore Lakeline") for eventual treatment at the West Point Treatment Plant.

The Kenmore Lakeline has a maximum hydraulic capacity of 26 mgd. In addition, the 4-MG Logboom Park Storage Facility is available downstream of the Kenmore pump station to store flows in excess of the Kenmore Lakeline capacity. During high system flows, typically during large rainstorm events, wastewater can exceed the hydraulic and storage capacity of the existing conveyance system, potentially resulting in SSOs and the release of diluted untreated wastewater. Historically, overflows have occurred from manholes at low points in the system along the Sammamish River east of the Kenmore Pump Station and from the Kenmore Lakeline in Lake Washington. One of the purposes of the proposed Brightwater System is to reduce the probability of SSOs to the Sammamish River and Lake Washington.

King County Conveyance System Design Requirements

Emergency flow conditions are situations that occur when the capacity of the King County conveyance system to transport and treat wastewater flows is exceeded. Events that cause these conditions to develop within the conveyance system are typically related to storm events combined with equipment or power failures. To minimize the probability of developing emergency flow conditions, King County currently specifies that all conveyance system pump stations have the following design requirements:

- A minimum firm capacity (pumping capacity with the largest pump out of service) to pump flows during a 5-year peak flow event
- A minimum peak capacity (pumping capacity with all pumps in service) to pump flows during a 20-year peak flow event
- An on-site backup generator to provide power for firm pumping capacity if the primary power feed is not available
- Backup control systems

Due to the increased flow volume and because of the importance to the Brightwater Conveyance System, the new pump stations would be more robustly designed to the following standards:

- A firm capacity with two standby pumps, instead of one, able to pump flows from a 5-year peak flow event
- An ability to pump the 20-year peak flow event with one standby pump available
- Have both a secondary utility power feed and an on-site, diesel generator
- The standby power would be sized to provide power for full pumping at average flows and loads. (Subject to load confirmation in Predesign, the system would be capable of pumping peak flows).

The robust design of the Brightwater Conveyance System will result in a system that has a lower system failure probability, thereby reducing the risk of emergency flow conditions due to equipment failure in the service area.

Normal Flow Management Goals and Strategies

For most of the time, the existing and proposed conveyance facilities in northern King County and southern Snohomish County would be operating at approximately 10 to 30 percent of their respective rated capacities. The northern King County storage facilities, which will be described later, would be empty and pump stations would only be operating at less than firm capacity. In addition, the backup generators and control systems would not be used.

During normal operating conditions, the proposed conveyance system would divert flow from several service basins that are currently conveyed to the West Point and South Treatment Plants to the new Brightwater Treatment Plant. Table 1 lists the basins that would be diverted at each of the portals for the proposed Route 9 and Unocal System Alternatives. Figure 1 shows the location of the basins diverted by the Route 9 Alternative while Figure 2 shows the same basin information for the Unocal System.

During normal flow conditions, King County would also use the flow management strategy of diverting Brightwater flows back to the West Point or South Treatment Plants while performing routine maintenance on Brightwater Treatment System facilities.

Table 1. King County Basins Diverted to the Brightwater Treatment System

System Alternative	Basins diverted at:		
	Portal 11	**Portal 44**	**Portal 41 (Route 9) Portal 14 (Unocal)**
Route 9	Bothell Kenmore Section 5 Swamp Creek – King Inglewood Lake Forest – Snohomish[1] Lake Forest[1]	Swamp Creek – Snohomish Portions of Swamp Creek – King	Hollywood PS basins Woodinville SE East Woodinville Woodinville Bear Creek – King Cross Valley North Creek – Snohomish North Creek - King
Unocal	Bothell Kenmore Section 5 Swamp Creek– Snohomish Swamp Creek – King Inglewood Lake Forest – Snohomish [1] Lake Forest [1]	Not Applicable	Hollywood PS basins Woodinville SE East Woodinville Woodinville Bear Creek – King Cross Valley North Creek – Snohomish North Creek – King

Notes:
[1] Lake Forest and Lake Forest-Snohomish basins would be diverted to Brightwater some time after 2020.

The flow through the Kenmore Lakeline would be reduced to below the capacity of the pipeline as a result of the flow diversions to the Brightwater System. Flows from the following basins would continue to be conveyed through the Kenmore Lakeline for processing at the West Point Treatment Plant:

- Lyon
- Ballinger – Snohomish
- Ballinger – King
- McAleer/Lyon
- Lakeline

Flows from the Lake Forest and Lake Forest-Snohomish basins would also initially be conveyed to the Kenmore Lakeline but would be diverted to the proposed Brightwater influent tunnel some time after 2020.

These basins are also indicated in Figures 2 and 3.

Emergency Flow Management Goals and Strategies

The King County emergency flow management policy is to avoid SSOs throughout the wastewater conveyance system. King County has several strategies available to help prevent SSOs when emergency flow conditions develop. However, it is possible that when King County's emergency flow strategies have been fully utilized and high flow conditions persist, SSOs may occur. The Brightwater System design provides a safety relief point so that an emergency SSO would occur into selected natural receiving waters rather than causing backups into individual pump stations.

The proposed Brightwater Conveyance System will have three major flow management strategies (discussed below) available to deal with high flow conditions:

- Flow transfers to other treatment plants
- Using offline storage facilities
- Controlled surcharging of the existing Bothell-Woodinville Interceptor and the proposed influent tunnel

The practical implementation of flow management would involve combinations of these three strategies. However, during extreme flow events or operational emergencies, a proposed safety relief point would discharge excess flow to the Sammamish River, immediately upstream of the confluence with Lake Washington at a known location that can be monitored. This safety relief point would only be used in extreme emergencies when all flow management strategies fail to avoid surcharging local systems.

Flow Transfer to Other Treatment Plants

Flows generated in some areas of the Brightwater Treatment Plant service area could be redirected to either of King County's other two treatment plants, the West Point Treatment Plant in Seattle and the South Treatment Plant in Renton, or to the Edmonds Treatment Plant in Edmonds. Flow transfers to the West Point Treatment Plant would be routed by gravity through the existing 26-mgd Kenmore Interceptor Section 2 ("Kenmore Lakeline"). Additional flows into the Kenmore Lakeline could be sent by the Kenmore Pump Station (either existing or new station, depending on the conveyance system alternative). The flow volumes that could be transferred would depend upon the available capacities at existing facilities. Such a diversion may not be possible if peak flows are occurring throughout the

King County service area. However, such a diversion could be accomplished if high flows are from rainfall primarily localized in the Brightwater service area or as a result of equipment failures during non-storm periods.

Similarly, flows could be transferred to the South Treatment Plant by redirecting the North Creek and York Pump Stations. The North Creek Pump Station could pump flows to the York Pump Station, which in turn could send the flows to the Eastside Interceptor. The flow volume that could be redirected to the South Treatment Plant would be limited by the York Pump Station and the Eastside Interceptor capacities (58 mgd and 70 – 210 mgd, respectively). The upper reaches of the Eastside Interceptor are the primary constraint in directing peak flows to the South Treatment Plant, with only a total of 12 mgd of diversion available before the capacity of the pipeline is exceeded. There are no hydraulic constraints in the lower (more southern) reaches of the Eastside Interceptor.

Making these flow transfers would take a minimum of 30 minutes to redirect the flows from the York Pump Station from the North Creek area to the Eastside Interceptor by operating pipe valves and regulator gate settings and then starting the North Creek Pump Station.

Subject to an emergency flow management agreement, the Lake Ballinger Pump Station would be able to direct flows generated in the Lake Ballinger–Snohomish and Lake Ballinger–King service basins to the City of Edmonds Treatment Plant.

Flow Storage Facilities

Two offline storage facilities will be used during emergency flow conditions. The 4-MG Logboom Park Storage Facility consists of two 132-inch diameter pipes, approximately 2,900 feet in length, located at the north end of Lake Washington, between the Kenmore Pump Station and the Logboom Park Regulator Station. The 6-MG North Creek Storage Facility is currently under construction next to the North Creek Pump Station and will be online in late 2003.

The benefits of these storage facilities vary depending on the flow volumes and the type of emergency flow condition. To evaluate the relative availability of storage for each alignment alternative, the flow volume entering the storage facilities was assumed to be 170 mgd, the estimated flow during a 20-year peak flow event in 2050. This volume represents a worst-case scenario of a 170-mgd pump station going offline; a partial shutdown of a pump station or smaller flow volumes would result in greater storage volumes.

Controlled Surcharge of Conveyance Lines

Some conveyance lines can be surcharged in emergencies to provide additional storage in the conveyance system. For Brightwater, the principal storage would come from the influent tunnel immediately upstream of the treatment plant. The volume of available storage from the influent tunnel is dependent on flow volumes, tunnel slope and diameters, and surface elevations. An additional 2 MG of storage is available in the existing Kenmore/Bothell-Woodinville Interceptor upstream of the Kenmore Pump Station. As with the flow storage facilities, the storage evaluation was conducted using the 170-mgd peak flow for 2050.

Flow Management Strategies

The available emergency flow management strategies will vary among the Brightwater Treatment Plant conveyance alignment alternatives. The system available storage volumes for each alternative are summarized in Table 2.

Table 2. Brightwater System Available Storage Volume

Proposed Influent Alternatives	Available Storage Volume		
	In Existing Facilities[1]	Proposed Influent Tunnel[2]	Total
Route 9 combined influent/effluent tunnel[3]	12.0 MG	11.3 MG	21.3 MG
Unocal influent tunnel[4]	12.0 MG	11.6 MG	21.6 MG

Notes:

1. Sum of volume in Logboom Park Storage Facility (4 MG), North Creek Storage Facility (6 MG), and Bothell-Woodinville Interceptor (2 MG).
2. Volume calculated assuming Year 2050 20-year peak flow at treatment plant is 170 mgd.
3. Tunnel would be a 120-inch inner diameter (ID) pipeline from proposed Portal 11 to proposed Portal 44, a 132-inch ID pipeline from Portal 44 to Portal 41 and dual 96-inch ID pipelines from proposed Portal 41 to the Route 9 site alternative.
4. Tunnel would be 150-inch ID from proposed Portal 14 to proposed Portal 11.

Route 9 Influent Tunnel Alternative

Figure 3 shows flow sources and conveyance to the Route 9 site for the year 2050 design peak wet weather flow rates under normal operating conditions. Service area flows would be conveyed to the locations of proposed Portals 11 and 41, and from there, the flows would enter the proposed influent tunnel to an influent pump station located at the Route 9 site alternative. Use of available storage in the existing storage facilities and in the proposed influent tunnel would not be required under normal conditions. Most of the existing conveyance system and the entire proposed Route 9 influent tunnel would be gravity flow. The exception would be flow from the Redmond/Lake Sammamish area, which would be pumped via the existing York, Hollywood, and Woodinville Pump Stations to the North Creek area. From there, the wastewater would flow by gravity to the Brightwater tunnel at Portal 41.

Emergency flow management strategies, including diversion through available conveyance to the West Point or South Treatment Plants, or to storage, are depicted in Figure 4. The Route 9 influent conveyance system has an estimated 11.6 MG of available storage.

The Route 9 treatment plant system has one other flow management strategy that could be implemented. Rather than discharging wastewater from the safety relief point into the Sammamish River after all available storage is filled, up to 170 mgd of dilute untreated wastewater would bypass the treatment processes at the plant site and flow into the effluent conveyance system for eventual discharge into Puget Sound. The goal of this strategy is to force the SSO to occur in a highly mixed marine environment rather than into an urban freshwater body, and thereby lessen the potential impact of such an event. This strategy would only be implemented if the influent pump station at the treatment plant was operating but the rest of treatment plant can not treat the flows, the previous three flow management strategies were fully utilized, and an SSO was still imminent.

Unocal Influent Tunnel Alternative

Figure 5 shows the sources and conveyance to the Unocal site of the design peak wet weather flow rates under normal operating conditions. Service area flows would be conveyed to Portal 11, and from there, flows would be pumped via a proposed 170-mgd pump station through new tunneled force mains and gravity sewers to a new influent pump station at the Unocal site alternative. Most of the service area flow would be conveyed to Portal 11 by gravity, except for the flow from the Redmond/Lake Sammamish area that must be pumped by the existing York, Hollywood, and Woodinville Pump Stations. Some upgrading and piping revisions would be required at these three existing stations to configure them for Brightwater service. York would need to be configured for substantially different pump duty for conveyance to either Portal 14 or the Eastside Interceptor.

Emergency flow management strategies, including flow diversions to the West Point and South Treatment Plants or to storage, are depicted in Figure 6. The Unocal conveyance tunnel has been designed to provide a similar volume of available storage as the Route 9 tunnel. Since the tunnel reach between Portals 14 and 11 is shorter than the Route 9 tunnel reach from Portal 11 to the Route 9 site, the additional available storage volume would be provided by increasing the inner diameter of the tunnel from 120 inches to 150 inches.

The Unocal treatment plant system would also have the final option of discharging an unavoidable SSO into Puget Sound by allowing influent to bypass the treatment plant. The conditions for such a Unocal plant bypass would be if both primary and secondary power feeds were de-energized, the treatment plant was operating on standby power, the previous three flow management strategies were fully utilized, and the proposed pump station at Portal 11 was still operational. The maximum flow that could be bypassed to prevent an SSO into the Sammamish River would be limited by the capacity of the new Portal 11 pump station. An SSO into Puget Sound would result in fewer potential environmental impacts, as Puget Sound would provide greater dilution of the discharge plume as opposed to the smaller Sammamish River.

Unocal and Route 9 Effluent Tunnel Alternatives

The currently proposed Route 9 effluent systems do not have any significant storage opportunities because most of the tunnels would be full at all times to provide gravity flow from the Route 9 site to the outfall at Puget Sound, while the Unocal effluent system is too short to provide any storage between the treatment plant and the outfall. Any need to reduce flows through the effluent system for any system alternative would require flow diversions in the influent system, storing additional flows in the influent storage facilities, and temporarily stopping treatment plant processes.

Brightwater Safety Relief Point

As noted in the previous flow management discussion, untreated wastewater could overflow from the system into surface systems during extreme or prolonged wet weather conditions, multiple equipment failure scenarios, or combinations of both. Initially under these emergency conditions, the flow management strategies outlined above would be implemented to avoid or minimize a potential overflow. However, when all available flow management strategies were implemented, but flows in the conveyance system continued to exceed capacity, an overflow of untreated wastewater, referred to as an SSO, could occur at a safety relief point in the conveyance system. The purpose of the safety relief point is to provide a known location where an SSO can be monitored instead of unmonitored discharges from multiple manholes adjacent to the Sammamish River and Lake Washington. Construction of a safety relief structure would enable operators to protect the conveyance system during unusual combinations of events (such as pump station failures during large storms) by diverting flows directly into the Sammamish River. Diversion of an SSO underwater to the Sammamish River (at a single point rather than multiple uncontrolled points) would provide more rapid and greater dilution of the discharge and eliminate the potential for the discharge to affect private property, roads, isolated or small waterbodies, wetlands, and riparian buffers and minimize potential effects to human health.

Both the proposed Route 9 and Unocal system alternatives would have the safety relief point located adjacent to the Sammamish River in Kenmore. The underground facility would consist of a regulator structure at the existing King County Kenmore Interceptor Section 5 and dual 72-inch pipes leading from the structure to an underwater discharge point 325 feet south of the north bank of the Sammamish River, east of the 68th Avenue NE Bridge. Each pipe would terminate with a metal grate to prevent fish and other objects in the Sammamish River from entering the pipes. The ends of the pipelines would be angled to avoid obstructing the river and the crown of the discharge pipes would be a minimum of two feet below the lowest low water elevation in the Sammamish River. Pipe material would be reinforced concrete, fiberglass reinforced plastic, ductile iron, or high-density polyethylene. Installation would involve open-cut construction in the riverbank. Figure 7 is an aerial photograph showing the proposed safety relief point in relation to the proposed Brightwater Route 9 and Unocal conveyance facilities at Portal 11.

The control structure would be a two-chamber concrete vault, approximately 28 feet by 32 feet. One chamber would be situated over the existing Kenmore Interceptor. The second chamber would be separated from the first by a weir. This chamber would be constantly full with river water. The bottom of the weir would be located six inches above the maximum water surface elevation in the Sammamish River to prevent river water from entering the conveyance system.

If the influent tunnel and other existing storage facilities are filled and flow diversions are initiated, but flows into the conveyance continue to exceed the capacity of the Brightwater system, wastewater would begin surcharging throughout the conveyance system, including the Kenmore Interceptor. Once the Kenmore Interceptor is surcharged to a height equal to the weir elevation, the stormwater-diluted wastewater would spill over the weir by gravity into the second chamber and flow out through the dual 72-inch pipes to the Sammamish

River. The second chamber would contain instrumentation that will send an alarm to the King County conveyance system control center and calculate the approximate volume of wastewater exiting the conveyance system. Once the emergency event passed, the water levels would subside to below the weir and wastewater would stop flowing from the Kenmore Interceptor into the Safety Relief Point pipes. The structure and the connecting pipes would be cleaned after the event.

Safety Relief Point Probability Model Development

A probability computer model was used to estimate the discharge frequency of the safety relief point, given various data inputs for mechanical reliability, electrical/power availability, and tunnel design parameters. The inputs were combined with fixed model parameters, such as flow event occurrence probabilities, pump system capacities, and the volume of existing King County storage facilities, to generate probability estimates (in events per year) for SSO discharge from the safety relief point. This analysis does not consider the potential benefits of diverting flows to the West Point or South Treatment Plants during periods of high flows, or the option of allowing excess flow to bypass the Brightwater Treatment Plant and discharge into the highly-mixed marine waters of Puget Sound. Also, surge and pressure transients were not considered.

User Inputs

The inputs used by the model are categorized into three areas: mechanical reliability, electrical reliability, and tunnel design parameters. User inputs for the model are listed in Table 3.

Table 3. Probability Model User Inputs

Input Category	Specific Inputs
Electrical/ Mechanical/Control	Probability that any one dual-stage pump system goes offline Estimated time to repair one offline pump system
Power	Probability that primary power feed is tripped Probability that secondary power feed is tripped Estimated duration (*x*) of electrical outage to treatment plant (dual power feed failure) Estimated probability of electrical outage lasting *x* hours Probability that onsite standby generator operates normally
Tunnel Design	Tunnel diameter, length, and invert elevations from Portal 10 to 11 Tunnel diameter, length, and invert elevations from Portal 11 to 34/44 Tunnel diameter, length, and invert elevations from Portal 34/44 to 41 Tunnel diameter, length, and invert elevations from Portal 41 to treatment plant

Probability That Any One Dual-Stage Pump System Goes Offline

The influent pump station is currently designed with five pump systems for Phase I (130 mgd) and six systems for Phase II (170 mgd). Each system includes dual-stage pumping, interconnecting piping, variable frequency drives for each pump, and the associated controls and instrumentation.

The probability that a pump system would fail during operation due to mechanical problems such as ragging, overheating, or seal breakage; electrical problems such as out-of-phase power and voltage drops; or failure to restart, is based on typical pump station operational information. The model assumes that the probability of any pump system failing is independent of the other pump systems. Therefore, the probability of multiple pump systems failing is defined as:

$$P(n\ \text{pump systems failing}) = P(\text{any 1 system failed})^{n\ \text{systems failed}}$$

In addition, out-of-phase power or voltage drops are assumed to occur prior to a complete power outage at the influent pump station. For the required storage analysis, described later in this document, it is assumed that a total of one hour of power outage would occur at the influent pump station due to such poor power quality. The outage was assumed to occur as one of the following:

- Four pump systems operating at full capacity and requiring 15 minutes each to reset
- Two pump systems each requiring 30 minutes to reset
- One pump system requiring one hour to reset.

Estimated Time to Repair Offline Pump Systems

The pump repair time parameter is the estimated average time to repair an offline pump system and to return the system to full operational status. The time to return a pump system to service due to poor power quality is typically 15 minutes, while pump repair time due to broken seals, failed bearings, or broken gears can be more than several days.

Probability the Primary and Secondary Power Feeds Are De-energized

The proposed Brightwater Treatment Plant would be powered with two separate power feeds, with each power feed capable of powering the entire plant. This would allow operations to continue if one of the power feeds is de-energized. The influent pump station and plant would require the onsite standby generator only if both power feeds are de-energized.

SnoKing Substation circuit breakers B-1560 and B-1582 control the two power feeds that would supply the proposed Route 9 site alternative. The records the Bonneville Power Administration (BPA) supplied indicate the only time between 1999 to 2002 that circuit breaker B-1560 was tripped was July 22, 1999. A Puget Sound Energy gas line below the power feed had ruptured and the power feed was purposely de-energized for safety. There was no record of weather-related outages in the information supplied. There was no information older than 1999. Given the data, the annual probability of circuit breaker B-1560 tripping is approximately 25 percent (one outage in four years).
BPA circuit breaker B-1582 has tripped only once since January 1, 2000. The fault was a malfunction in the breaker. Again, based upon available information, the probability of B-1582 tripping was set to 33 percent (one outage in the last three years). Circuit breaker B-1582 is scheduled for replacement in 2003, which should further improve the power feed reliability of the system.

It was assumed that the power feed reliabilities to the Unocal Site Alternative would be the same as circuit breakers B-1560 and B-1582 to the Route 9 Site.

Probability of Electrical Outage to Treatment Plant of Estimated Duration (x)

The outage caused by BPA circuit breaker B-1560 lasted 5 hours 47 minutes, while the fault with B-1582 was reset in less than 5 seconds. In addition, the BPA system average interruption duration index (SAIDI) for the last 5 years is 12 minutes, indicating that the total annual outage time throughout the BPA service area (Washington, Oregon, Idaho, and western Montana) is 12 minutes.

To provide a reasonable estimate with the limited data, the power outage duration used in the model was 5.8 hours for both proposed Route 9 and Unocal Site Alternatives, which is the longest outage duration of record. Based upon available data, a combined (dual) outage could occur once every 9 to 16 years. The associated annual probability range for such dual power feed outages is 6 to 11 percent.

Probability that Onsite Standby Generator is Available When Needed

The onsite standby generator parameter is the estimated probability that the generator starts when needed if the two power feeds are de-energized. King County inspects and maintains the pump station generators as part of its standard maintenance program. As such, the reliability of the generator was estimated to be between 90 and 95 percent.

The model assumes that if the generator fails, then one of the two power feeds would return to service before the generator was repaired and operational. This assumption is valid only for power outages of less than four hours. For outages longer than four hours, the plant operators would most likely be able to repair and start the generator before the primary or secondary feeds returned to service.

Tunnel Design Parameters

The tunnel design parameters (diameter, slope, length, and invert elevations at portals) are based upon current predesign tunnel plans, profiles, and cross sections. The model uses these parameters to estimate the volume of storage available (volume in excess of the wastewater volume in the tunnel) for a 170 mgd peak influent flow event (flow from an approximately 1-in-20 years event). The model does not vary as a function of flow volume.
Assumptions used to determine the storage volume are:

- The proposed Route 9 influent tunnel consists of a single pipe from Portals 11 to 41 and dual pipes from the proposed Portal 41 to the Route 9 Site Alternative.
- The proposed Unocal tunnel would be a single pipe from Portal 14 to the proposed influent pump station at Portal 11. There would be no available storage between the proposed influent pump station and the Unocal site alternative, as the tunnel would be filled with force mains.
- The proposed Route 9 and Unocal tunnel pipe diameters are constant between portals.
- The gravity sections of the Route 9 and Unocal influent tunnels would contain a cunette (i.e., a gutter) to maintain self-cleaning velocities during low flows. The cunette is assumed to occupy ten percent of the tunnel cross-sectional area.

Fixed Model Parameters

The fixed parameters in the probability model are the flow recurrence probabilities, volumes of the existing storage facilities, and design parameters for the influent pump station and treatment plant.

Selected flow events were used in the model to evaluate the probabilities of a number of possible combinations of events. The selected events (listed in Table 4) represent the most commonly used intervals for forecasting purposes.

Table 4. Flow Events Included in the Safety Relief Discharge Model

Event	Equivalent Annual Probability	Phase I Peak Hour Flow (mgd)	Phase II Peak Hour Flow (mgd)
1 yr	1.00	93	122
2 yr	0.50	102	133
5 yr	0.20	113	148
10 yr	0.10	122	160
20 yr	0.05	130	170
30 yr	0.03	136	178
40 yr	0.03	139	182
50 yr	0.02	142	186
100 yr	0.01	151	197

A conservative model assumption is that the peak-hour flow continues for the duration of the flow event rather than having decreasing flow after the peak hour. The result of this assumption is that the storage time provided by the existing and new storage in the Brightwater service area is underestimated for all flow events or power outage durations exceeding one hour. The magnitude of the underestimation increases correspondingly with longer flow events or outage durations.

While the proposed Brightwater System would have the capacity to divert flows to the West Point and South Treatment Plants, the available capacities of the treatment plants and conveyance system to the respective plants are limited for the larger flow events that are used in the model. It is assumed that large flow diversions cannot be made during any of the flow events for both Phases I and II.

Existing storage facility volumes are listed in Table 5. It is anticipated the Logboom Park Storage Facility and some of the proposed influent tunnel would be used to attenuate peak flows through the Kenmore Lakeline in the decade of 2030. This volume was subtracted from the sum of the existing and proposed storage volume in the Phase I model. The volumes used for Kenmore Lakeline flow attenuation are listed in Table 6. Since it is anticipated that Kenmore Lakeline flow volumes would not require attenuation in Phase II of the Brightwater System with the end of temporary Brightwater flow diversions to the West Point Treatment Plant (done to maximize the use of existing treatment capacities and delay the expansion of all King County treatment plants), it is assumed that all storage facilities are empty at the beginning of the peak flow event.

Table 5. Existing King County Storage Facilities Volumes

Storage Facility	Volume (MG)
Logboom Park Storage Facility	4
Bothell-Woodinville Interceptor	2
North Creek Storage Facility (under construction)	6

Table 6. Kenmore Lakeline Flow Attenuation Volumes in Phase I Model

Flow Event Interval	Volume (MG)
1 year	4.0
2 years	4.1
5 years	5.4
10 years	6.7
20 years	8.2
30 years	9.9
40 years	10.9
50 years	11.9
100 years	14.3

The influent pump station is proposed to have a capacity of 140 mgd for Phase I, with one standby pump, and 170 mgd in Phase II, with one standby pump. If the primary and secondary power feeds fail, pumping capacity of the Brightwater Treatment Plant decreases to 70 mgd because the standby generator is proposed to be sized to power two or three pumps (2 pumps × 35 mgd/pump = 70 mgd).

Analysis Process

The process flowchart for the model is shown in Chart 2. The shaded boxes are the user-defined inputs while the white ovals indicate steps within the model. The shaded oval indicates the final answer.

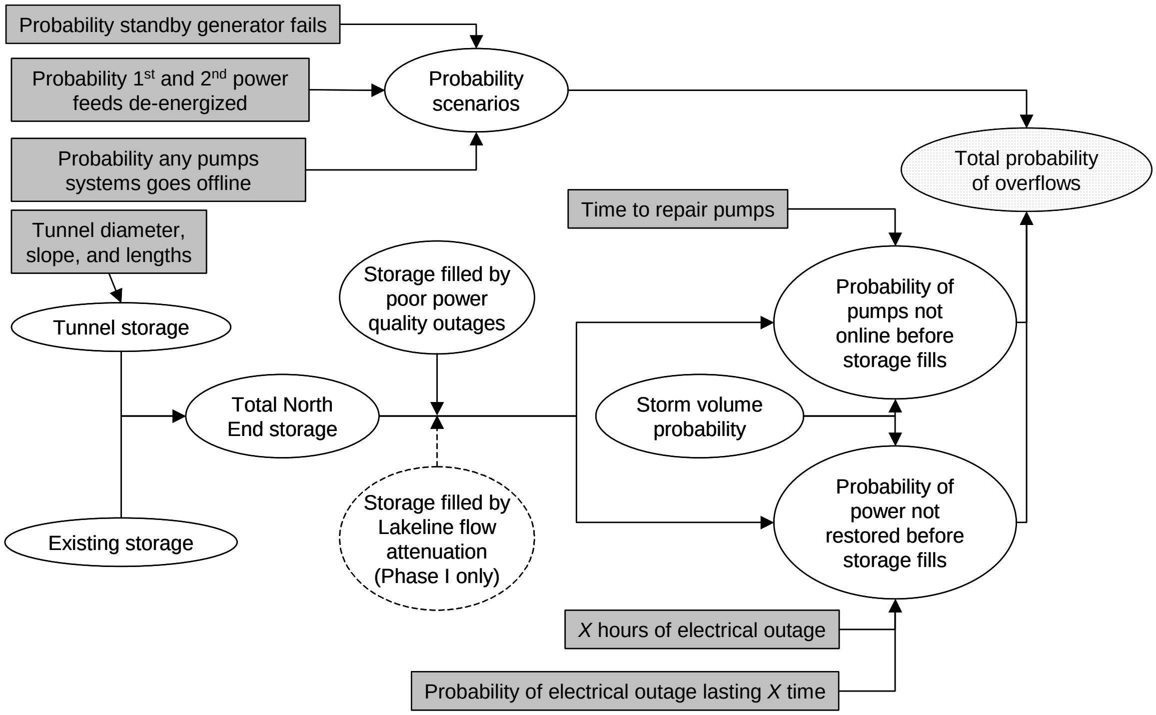


Chart 2. Safety Relief Point Discharge Probability Model Flowchart

Probability Scenarios

There are 21 combined event probability scenarios considered in the model, each of which defines a particular combination of pump system, power feed, and standby generator status. The scenarios are listed in Table 7.

Table 7. Safety Relief Point Probability Scenarios

Scenario	Power Feed Status	Generator Status	Number of Pump Systems Online	Influent Pump Station Capacity (mgd)	
				Phase I	Phase II
A	At least 1 online	Not used	6	N/A	170
B	At least 1 online	Not used	5	140	170
C	At least 1 online	Not used	4	140	140
D	At least 1 online	Not used	3	105	105
E	At least 1 online	Not used	2	70	70
F	At least 1 online	Not used	1	35	35
G	At least 1 online	Not used	0	0	0
H	Both offline	Used	6	N/A	70
I	Both offline	Used	5	70	70
J	Both offline	Used	4	70	70
L	Both offline	Used	3	70	70
K	Both offline	Used	2	70	70
L	Both offline	Used	1	35	35
M	Both offline	Used	0	0	0
N	Both offline	Failed	6	N/A	0
O	Both offline	Failed	5	0	0
P	Both offline	Failed	4	0	0
Q	Both offline	Failed	3	0	0
R	Both offline	Failed	2	0	0
S	Both offline	Failed	1	0	0
T	Both offline	Failed	0	0	0

The probability for each scenario occurring is the product of the individual probabilities for the power feeds, generators, and pumps. For example, assuming the two power feeds have failed 33 percent and 25 percent of the time, respectively, the generator is 95 percent reliable, and the pump systems are online 90 percent of the time, the annual probability of Scenario J is:

$$P(J) = (0.33)(0.25)(0.95)(1-0.90)^2 = 0.00078$$

For Scenarios A through G, the user-defined standby generator availability value was replaced with a dummy value of 100 percent to reflect the fact that the generator is not used when the power feeds are online. In addition, Scenarios A, H, and N in the Phase I model were assigned a probability of zero to reflect the fact that the Phase I system has a maximum of five pump systems installed. The Phase II influent pump station would have six pump systems installed.

The sum of the scenario probabilities in both the Phase I and II models is 1.00 (unity).

Total North End Storage

The volume of storage in the north end of the King County service area is calculated as the sum of the volume of the existing storage facilities and the storage available in the new Brightwater Influent Tunnel. The Brightwater volume was calculated using the tunnel design parameters entered by the user.

Probability of Pump Systems Not Online before Storage Fills

Discussions with King County indicate that typical pump systems have a mechanical failure probability range of one to two percent. In addition, it is estimated that the probability that pump systems go offline due to poor power quality is four times that of the mechanical failure rate. Therefore, pump systems are estimated to be operational 95 percent of the time using a high mechanical reliability value (1.00 – 0.01 mechanical failure – 0.04 electrical failure) and 90 percent of the time using a low reliability value (1.00 – 0.02 mechanical failure – 0.08 electrical failure).

Probabilities for not repairing the pump systems before available storage is filled are evaluated by using a computer spreadsheet macro to calculate the flow exceeding the capacity of the influent pump station. These were calculated for the range of flow events listed in Table 4 for each of the scenarios in Table 7, in a series of time steps. The time steps are 25 percent of the pump system repair times. The excess flow is diverted to storage and the excess flow volume reduces amount of available storage. After every four time steps, an additional pump is brought online and the capacity of the influent pump station is increased. The macro for each flow event and pump system returns either the time for which available storage volume is exceeded or indicates that storage is not exceeded, with the given the number of pumps, the volume of the flow event, and the pump system repair times.

Since Scenarios N through T assume that the power feeds and standby generator are not available, the pump systems probabilities are set at 100 percent to reflect the fact that the storage will be filled when the pumps are not running.

Probability of Power Not Restored before Storage Fills

The macro calculating the probability that power is not restored prior to storage being filled is the same as the pump system macro, with the following two exceptions:

- The formula only considers zero, one, and two pump systems operational because the standby generator is only sized to power up to two pump systems.
- The number of hours of storage time provided is compared against the user-defined power outage duration. If the storage time is greater than the power outage time, then it is assumed that the influent pump station is restored to full capacity and storage is never exceeded.
- The potential discharge result is multiplied by the user-defined probability of the electrical outage lasting *x* hours.

Scenarios A through G (both power feeds are available) assign a dummy value of 100 percent to the probabilities of power feed down time and power not being restored to reflect the fact that power reliability is not a consideration for these scenarios. In addition, Scenarios N through T assume the power probabilities are set at 100 percent to reflect the fact that the storage will be filled when there is no power and the pumps are not running.

Limited records indicate that the each of the BPA power feeds to the Brightwater Treatment Plant are offline for any given amount of time once every three to fours years (25 to 33 percent of the time). Multiplying the probabilities of the two power feeds together gives a probability range for both power feeds simultaneously offline as 6.3 to 10.9 percent (once in every 9 to 16 years).

Total Probability of Safety Relief Point Discharges

The total probability of discharge from the safety relief point is the cross product of the scenario probabilities, the probability that the pumps are not online before storage is filled, and the probability of the power not being restored before the available storage is filled. The probability is provided as both a numerical value and an equivalent recurrence interval.

Results

The probability that the Brightwater influent pump station is capable of pumping 170 mgd (the estimated 20-year flow event in the Brightwater service area in 2050), is shown in Chart 3 as a function of power feed and pump system reliability. The probabilities shown represent the combined probabilities of Scenarios A and B in Table 7.

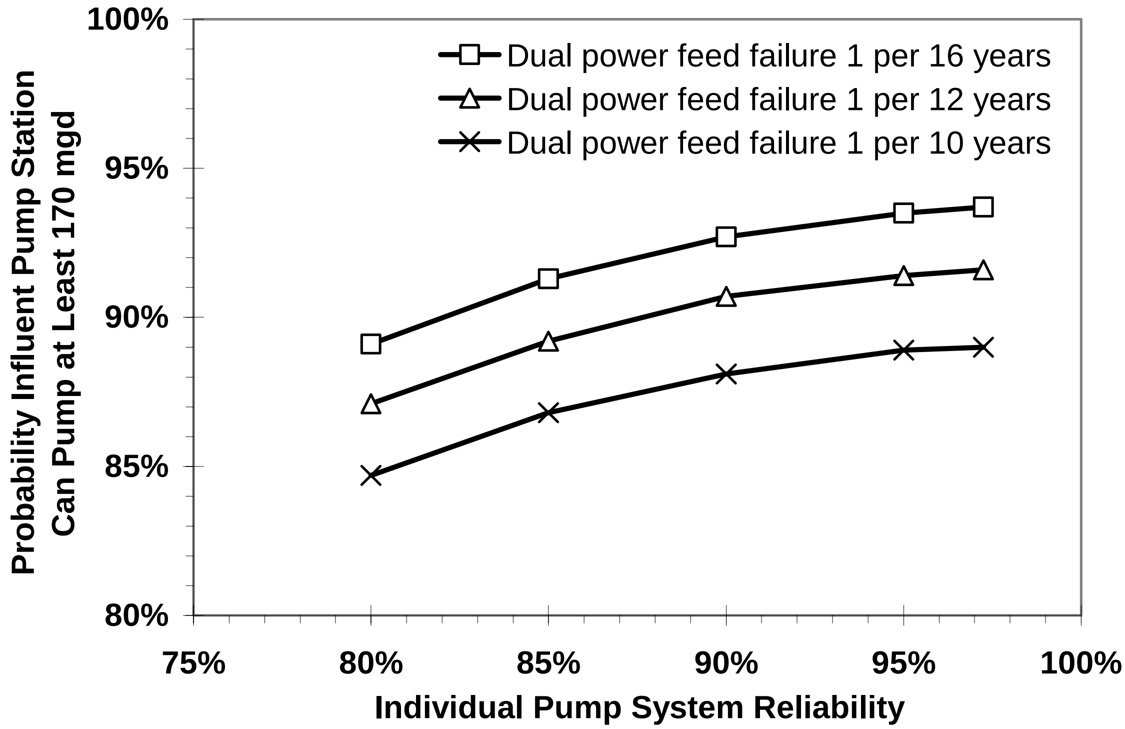


Chart 3. Probability of Influent Pump Station Capable of Pumping at Least 170 mgd

Given the reliabilities presented previously, the influent pump station would be capable of handling at least the 20-year flow event (130 mgd for Phase I and 170 mgd for Phase II) over 90 percent of the time on an annual basis. Combining the probability of Scenarios A and B with the probability of a flow event exceeding the capacity of influent pump station produces a probability of one to two percent annually (equivalent to a 1-in-50 to 1-in-100 years occurrence) that some of the influent storage will be used to prevent a safety relief point discharge.

The probability that storage will be used due to complete electrical failure at the treatment plant is also small due the presence of the dual power feeds and the onsite standby generator. Estimated probabilities for electrical outage at the treatment plant are shown in Chart 4 for various power feed and standby power reliabilities (the graph represents the combined probabilities of Scenarios N to T from Table 7). Again noting that the probability that both BPA power feeds are offline is 8.3 percent (once every 12 years, on average) and that King County pump station standby generators are available 90 percent of the time when needed, the risk that influent storage will be used is under one percent on an annual basis (greater than 1-in-100 year occurrence).

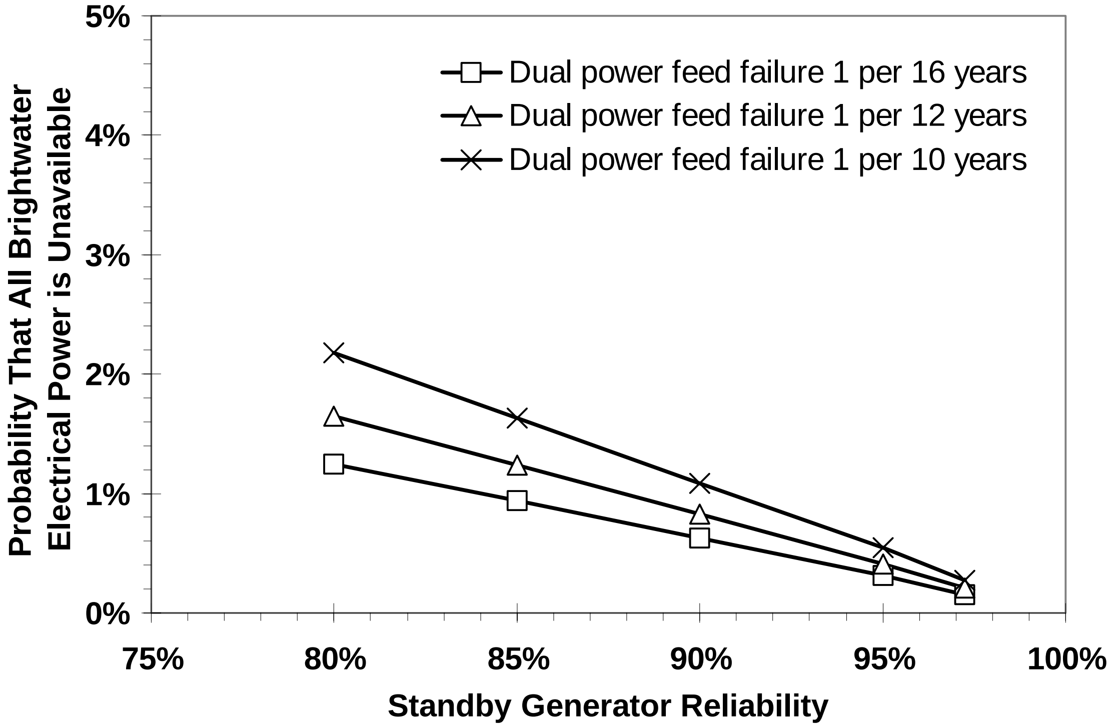


Chart 4. Probability that All Electrical Power is Unavailable

In summary, the top three operating conditions for the influent pump station, and the associated scenarios and probabilities, are listed in Table 8. The remaining scenarios have a combined probability of less than 0.01 percent.

Table 8. Top Three Scenario Probabilities

Operating Condition	Probability Range (%)	
	"High" Reliability[1]	"Low" Reliability[2]
Influent pump station can pump at least 130 mgd in Phase I and 170 mgd in Phase II	94	88
Influent pump station limited to 70 – 140 mgd due to varying combinations of power feed outages and pump system failures	6	11
Complete power failure	0.3	1.1

Notes:
[1]: "High" reliability defined as each BPA power feed reliability is 75 percent and pump system and generator reliabilities are 95 percent.
[2]: "Low" reliability defined as each BPA power feed reliability is 67 percent and pump system and generator reliabilities are 90 percent.

Probability Analysis and Brightwater Influent Tunnel Design

Table 8 indicates that the Brightwater influent pump station is capable of pumping at least the 20-year flow event 88 to 94 percent of the time without using any new or existing storage. Storage could be required for the remainder of the time due to either power or mechanical difficulties or flow higher than the 20-year event. To estimate the storage needed for a 1-in-100 years combined scenario event, the following conservative assumptions were used:

- Influent pump systems reliabilities are 90 percent to reflect the high head, high capacity nature of the pumps.
- Repair time for each pump system is 96 hours (4 days).
- Standby generator reliability is 90 percent.
- Reliability of each BPA power feed is 67 percent.
- Both power feeds have de-energized and the standby generators are operating, thereby reducing pumping capacity to 70 mgd.

These assumptions are those used to develop the 11-percent occurrence probability described in Table 8. The calculation used to determine the flow recurrence that has to coincide with the described operating scenario to determine an event probability is:

$$\text{Flow Event Probability} = \frac{\text{Goal Probability}}{\text{Probability Influent Pump Station limited to 70 mgd}}$$

$$\text{Flow Event Probability} = \frac{0.01}{0.108}$$

$$\text{Flow Event Probability} = 0.093$$

The data used indicates that a flow recurrence of 0.093 (1-in-10.8 years) has a peak hourly flow of 161 mgd in Phase II. Since the longest power outage of record is 5.8 hours, it is assumed that the volume required to prevent an overflow would be full in 6 hours.

Based upon the storage/flow calculations included in Attachment A, the storage volume in the influent tunnel required for the 1-in-100 years combined scenario event is 11.1 MG. Therefore, the storage volume in the proposed influent tunnel must be increased by 1.5 MG, for a total of 12.6 MG, to account for the volume that would be stored in the proposed influent tunnel due to poor power quality-induced pump shutdowns. This volume reflects the resetting of four pump systems that were operating at full capacity (35 mgd each), with each resetting taking an estimated 15 minutes prior to complete power shutdown and transfer of the electrical load to the standby generator. This storage volume is conservative because it was assumed that the peak hourly flow would be constant for the 6-hour duration and the modeling used low system reliability probabilities.

Safety Relief Point Probability Analysis Summary

The Brightwater influent pump station would have an 88- to 94-percent annual probability of handling a 20-year flow event, without using wastewater storage, due to King County's high standard of equipment reliability and the presence of redundant power feeds to the treatment plant. The annual probability that wastewater storage would be required due to mechanical and/or electrical failures is 6 to 11 percent, while the risk of the influent pump station being shut down is one percent or less, depending the assumptions used.

A 1-in-100 years probability event in Phase II of the proposed Brightwater System is estimated to occur when both power feeds are offline and the standby generator is required to power two pumps during a peak flow of 161 mgd (approximately an 11-year flow). A 1-in-75 years probability event is estimated to occur during a peak flow of 156 mgd (approximately an 8-year flow) under similar power feed failure conditions. Chart 5 and Table 9 show the storage required to contain various discharge recurrences for both Phase I and Phase II for six hours, which is slightly longer than the known BPA outage duration of record for the two power feeds that would supply the Brightwater Treatment Plant.

The estimated tunnel volume requirements for all calculated discharge recurrences is higher for Phase I than Phase II due to the need to also contain attenuated peak flows through the Kenmore Lakeline in the decade 2030. Using "high" reliabilities and decreasing the required storage time would reduce the storage volume required.

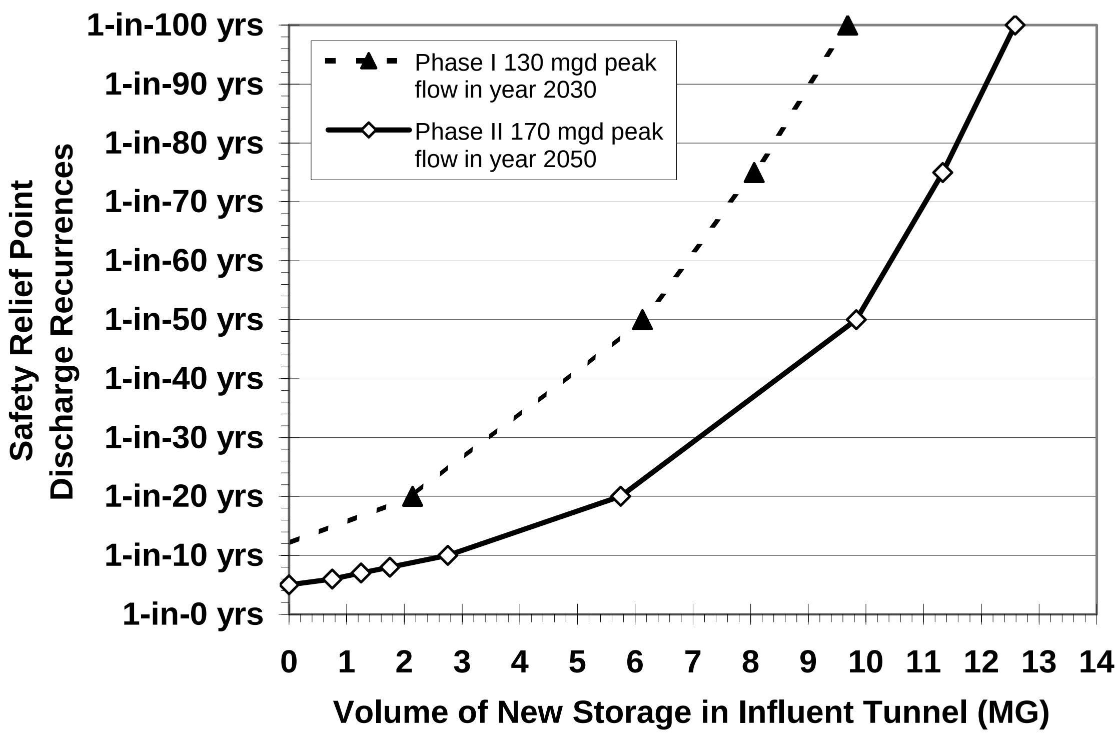


Chart 5. New Storage Volume Required to Prevent Safety Relief Discharge for Six Hours

Table 9. Storage Volume Required in Proposed Influent Tunnel

Safety Relief Point Discharge Recurrence[1]	Volume Required to Prevent Discharge for 6 Hours (MG)[2]	
	Phase I[3]	Phase II
1-in-20 years	2.1	5.8
1-in-50 years	6.1	9.8
1-in-75 years	8.1	11.3
1-in-100 years	9.7	12.6

Notes:

1. As a function of flow recurrence; pump system, generator, and power feed reliability; and pump and power repair times.
2. Assumes influent pump station is operating continuously for the 6-hour power outage duration and pump station experienced 4 pump system shutdowns (for 15 minutes each while operating at 35 mgd per pump) due to poor power quality prior to complete power outage (using a total of 1.5 MG of storage.
3. Volume includes the additional volume required to attenuate high flows through Kenmore Lakeline in the decade 2030.

Safety Relief Point Discharge Characterization

When all available flow management procedures have been implemented, but flows in the conveyance system continue to exceed system capacity, an overflow of untreated wastewater, or SSO, could occur at a safety relief point in the conveyance system. During this extreme flow condition, the purpose of the safety relief point would be to prevent SSOs from causing backups into individual pump stations and to provide a known overflow location that can be monitored. The characterization analysis discussed in this section is only for the safety relief point located in the Kenmore area, at or near the junction between the influent tunnel and the low point of the existing conveyance system. Discussions of the environmental impacts from such a discharge are found in the *Predesign Report for the Kenmore Pump Station Emergency Bypass* (Garry Struthers Assoc. 1998).

Wastewater from an SSO would be discharged from the structure using an outfall into the Sammamish River adjacent to 68th Avenue. Discharge would be through a proposed twin 72-inch-diameter outfall with the terminus approximately 55 feet into the river and 10 feet deep. Computer modeling was conducted to estimate the anticipated initial pollutant dilutions for discharge into the Sammamish River. Input parameters for the computer model were based upon existing, available data; no fieldwork was performed to collect missing data.

Chapter 173-201A of the Washington Administrative Code (WAC) identifies the surface water quality standards and mixing zone boundary requirements for surface waters. Although the discharge is not a treated effluent from a wastewater treatment plant, for comparison, initial dilution modeling is presented in recognition of adopted mixing zone boundary requirements.

Receiving Water Conditions

This section provides data obtained for the Sammamish River. This data was used as input into the initial dilution model as well as input for the comparison of adopted mixing zone boundary requirements and receiving water quality standards. Table 10 contains data obtained from King County for Locator 450 (boat launch near the river mouth at Lake Washington) and was based upon data from 1998 to 2002.

The critical river condition modeled was the 20-year, 24-hour recurrence interval flow. This interval was selected as a conservative estimate for the river flows during conveyance system conditions that could result in the 1-in-75 year safety relief point discharge. Research of available documents indicated the 10, 50, 100, and 500-year 24-hour recurrence interval flows for the Sammamish River at the mouth to be 2,300, 3,300, 4,300, and 5,600 cubic feet per second (cfs), respectively. Extrapolating a plot of this data provides a 20-year, 24-hour recurrence interval flow in the river of 2,800 cfs (Chart 6).

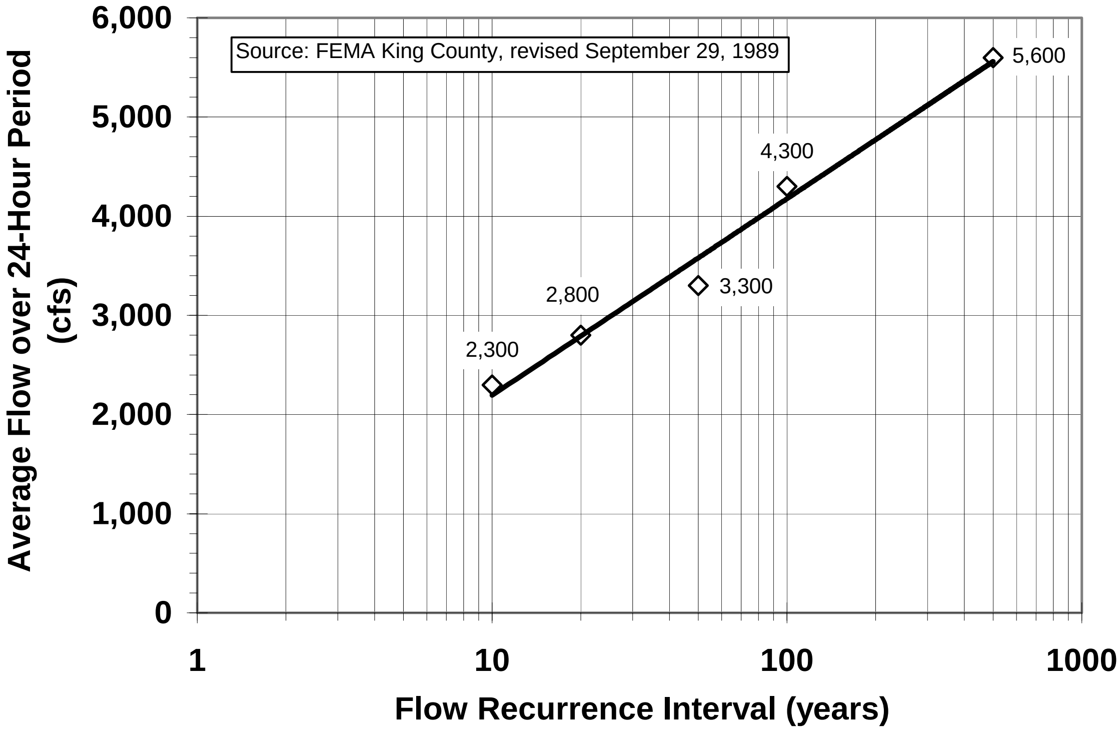


Chart 6. 24-Hour Flow Recurrence Interval at Mouth of Sammamish River

A Hydrologic Engineering Center (HEC) 2 model of the Sammamish River, prepared by Northwest Hydraulics, was obtained from King County. The 2,800-cfs river flow from Chart 6 was input into the HEC-2 model with an elevation of 13.4 feet for Lake Washington to obtain the cross section. Chart 7 shows the cross section for River Station 60, adjacent to the 68th Avenue Bridge.

Table 10. Sammamish River Initial Dilution Modeling Input Data[1]

Date	DO (mg/L)	Fecal Coliform (CFU/100 mL)	Hardness (as mg/L $CaCO_3$)	pH	Temperature (°F)	Turbidity (NTU)	Ammonia (mg/L)[2]	Arsenic (mg/L)[3]
January	10.0	88	-	7.2	44.0	6.3	0.025875	-
February	12.5	100	50.1	7.1	41.7	6.1	0.019000	0.000265
March	11.2	30	-	7.6	45.5	3.7	0.014500	-
April	9.3	145	-	7.2	50.5	3.6	0.016933	-
May	10.4	85	55.2	6.9	55.3	2.3	0.014250	0.000280
June	7.5	1,696	-	7.1	64.9	2.5	0.043300	-
July	6.9	218	-	7.3	68.2	2.6	0.037920	-
August	8.1	157	70.3	7.3	69.5	2.4	0.040967	0.000240
September	6.9	288	68.5	7.2	61.3	2.8	0.050180	0.000270
October	8.6	186	67.9	7.0	59.3	3.2	0.065280	0.000293
November	9.7	207	63.8	7.2	48.6	3.0	0.044933	0.000250
December	10.1	67	-	7.1	43.4	3.8	0.032600	-

Notes:
[1] From Locator 450; 1998-2002.
[2] Un-ionized NH_3.
[3] Recoverable portion of heavy metal.
[4] Dissolved portion of heavy metal.
- No data available.
Source: King County Department of Natural Resources and Parks

Table 10. Sammamish River Initial Dilution Modeling Input Data (continued)

Date	Cadmium (mg/L)[4]	Chromium (mg/L)[3]	Copper (mg/L)[4]	Lead (mg/L)[4]	Mercury (mg/L)[3,4]	Nickel (mg/L)[4]	Selenium (mg/L)[3]	Silver (mg/L)[4]	Zinc (mg/L)[4]
January	-	-	-	-	-	-	-	-	-
February	-	0.000507	0.000766	0.000085	0.000000810 0.000001240	0.001020	-	-	0.003140
March	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-
May	-	0.000307	0.000905	0.000103	0.000000925 0.000001035	0.000898	-	-	0.001965
June	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-
August	-	0.000159	0.000664	0.000071	0.000000577 0.000000662	0.001145	-	-	0.001230
September	-	0.000150	0.000638	0.000079	0.000001405 0.000000995	0.001080	-	-	0.001280
October	-	0.000262	0.000727	0.000067	0.000000597 0.000000603	0.001100	-	-	0.003600
November	-	0.000192	0.000700	0.000057	0.000001113 0.000000567	0.001182	-	-	0.001977
December	-	-	-	-	-	-	-	-	-

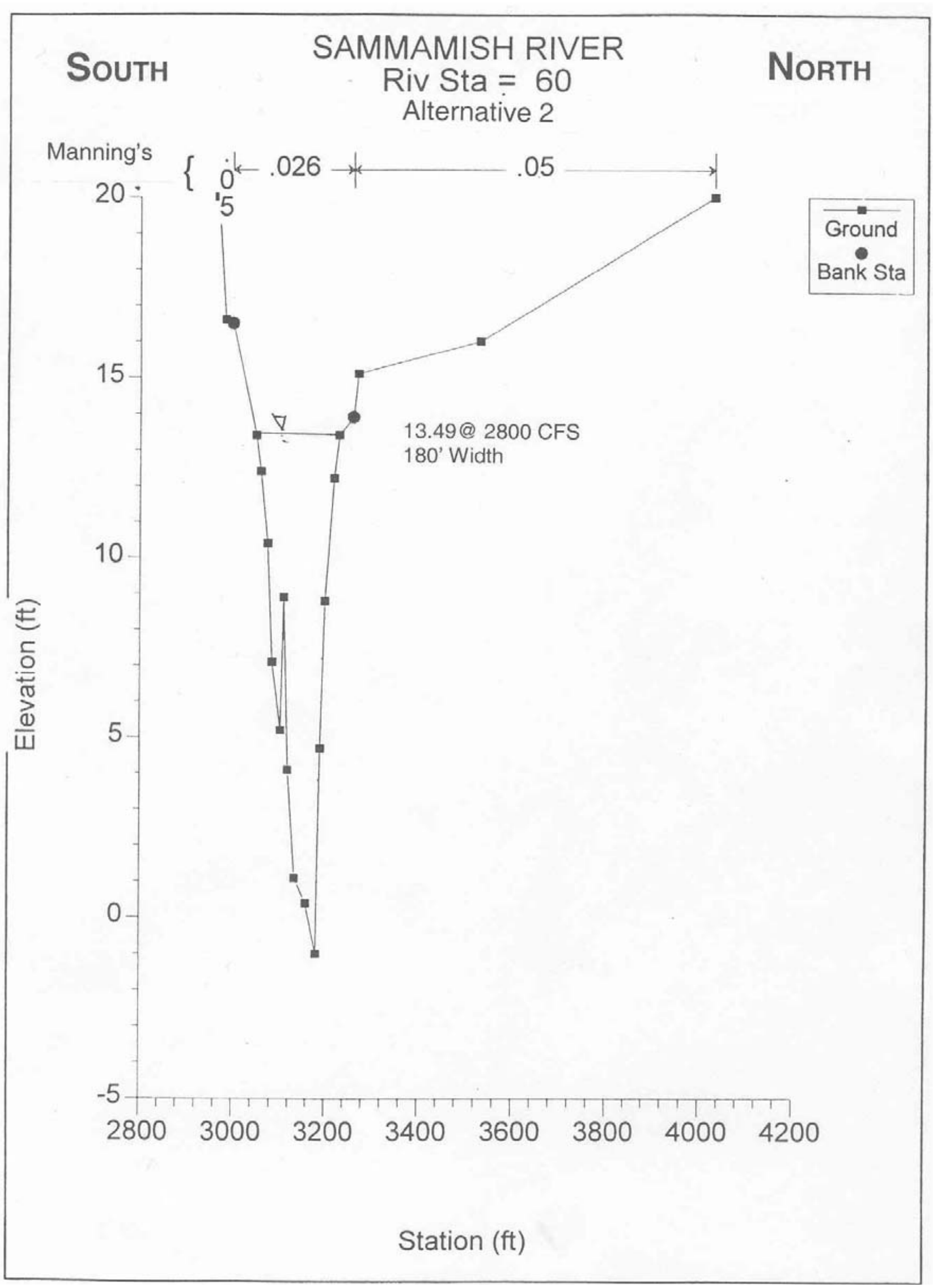


Chart 7. Sammamish River Profile at River Station 60

A summary of the results of the HEC-2 model for the Sammamish River is given in Table 11 (see Attachment B for the model output).

Table 11. Sammamish River HEC-2 Model Results

Parameter	Value
Water surface elevation	13.49 feet
Depth	14.50 feet
Velocity	2.08 ft/sec
Width	180 feet

Discharge Conditions

Table 12 lists data obtained from King County for the South Treatment Plant influent based upon data from 1993-2003 for heavy metals and 1997-1999 for all other measurements. Since both the South and proposed Brightwater service areas consist of separated local sewer systems, influent at the South Treatment Plant provides characteristics similar to the untreated wastewater to the Brightwater Treatment Plant. In comparison, a portion of the West Point service area consists of combined sewers, and the influent wastewater characteristics are diluted by the presence of stormwater.

Peak design discharge flow is estimated to be 170 mgd (2,800 cfs), the 20-year peak flow in the Brightwater service area in 2050 (see Chart 6). The impact analysis model assumes a constant discharge flow of 170 mgd; actual flows would decrease from the peak flows after one to two hours. For the model, it was conservatively assumed that the duration of the peak rate discharge would be six hours or approximately 42.5 MG.

Table 12. Wastewater Initial Dilution Modeling Input Data[1]

Month	DO (mg/L)[2]	Fecal Coliform (CFU/100 mL)	Hardness (as mg/L $CaCO_3$)	pH	Temperature (°F)	Turbidity (NTU)[2]	Ammonia (mg/L)[3]	Arsenic (mg/L)[4]
January	-	-	-	7.1	55	-	15.4	-
February	-	-	-	7.1	55	-	15.9	-
March	-	-	-	7.0	56	-	16.3	-
April	-	-	-	7.1	58	-	19.6	-
May	-	-	-	7.1	61	-	18.6	-
June	-	-	-	7.0	63	-	18.9	-
July	-	-	-	7.0	66	-	20.0	-
August	-	-	-	7.0	67	-	21.6	-
September	-	-	-	7.1	67	-	21.9	-
October	-	-	-	7.0	65	-	21.9	-
November	-	-	-	7.1	61	-	18.3	-
December	-	-	-	7.0	58	-	17.3	-
Average	4	-	-	7.1	61	100		-

Notes:
1 From South Treatment Plant influent; 1993-2003 for heavy metals, 1997-1999 for all other measurements.
2 Assumed from January 2003 South Treatment Plant influent data.
3 Un-ionized NH_3.
4 Recoverable portion of heavy metal.
5 Dissolved portion of heavy metal.
\- No data available.
Source: King County Department of Natural Resources and Parks

Table 12. Wastewater Initial Dilution Modeling Input Data (continued)

Month	Cadmium (mg/L)[5]	Chromium (mg/L)[4]	Copper (mg/L)[5]	Lead (mg/L)[5]	Mercury (mg/L)[4,5]	Nickel (mg/L)[5]	Selenium (mg/L)[4]	Silver (mg/L)[5]	Zinc (mg/L)[5]
January	0.000853	0.008442	0.024236	0.006822	0.000612 0.000153	0.025667	-	0.001644	0.043714
February	0.000748	0.007194	0.020996	0.006267	0.000343 0.000086	0.038750	-	0.001575	0.025576
March	0.000752	0.011170	0.020609	0.008338	0.000626 0.000157	0.024000	-	0.001585	0.026265
April	0.000867	0.007663	0.021049	0.007060	0.000491 0.000105	0.025333	-	0.001638	0.027007
May	0.000918	0.007175	0.024021	0.007657	0.000454 0.000114	0.033000	-	0.001706	0.029595
June	0.000712	0.007980	0.023006	0.007914	0.000433 0.000108	-	-	0.001880	0.030624
July	0.000706	0.007381	0.022689	0.008655	0.000556 0.000139	0.024000	-	0.001871	0.030540
August	0.000729	0.007860	0.024832	0.008167	0.000452 0.000113	0.031750	-	0.001969	0.033703
September	0.000830	0.007422	0.023453	0.007933	0.000386 0.000097	0.060333	-	0.001996	0.031760
October	0.000738	0.006759	0.022305	0.007364	0.000451 0.000113	0.025667	-	0.001874	0.030476
November	0.000745	0.007065	0.021246	0.007538	0.000419 0.000105	0.026286	-	0.001772	0.027526
December	0.000797	0.006492	0.019415	0.008880	0.000708 0.000177	0.029000	-	0.001656	0.023942

Mathematical Model Calculations

A submerged outfall discharge is characterized by two distinct zones of mixing: nearfield and farfield. Nearfield mixing is characterized by rapid dissipation of a plume's momentum. This momentum, directly related to the initial velocity, defines the plume trajectory and dilution factor. Farfield mixing is characterized by the receiving water properties. There are EPA-approved hydrodynamic computer models in which a mathematical approximation can be made in determining a dilution factor (e.g., PLUME and RIVPLUME). The models are utilized to "estimate" the dilution factor and can be within $\pm$25 percent of the actual dilution factor determined in the field. The reason for the range of accuracy is that the model cannot account for every variable in a natural environment. Such variables include the receiving water's vertical and horizontal profiles.

Mixing in this initial dilution modeling will be discussed in terms of a "dilution factor." The dilution factor is commonly used in EPA-approved hydrodynamic computer models. A distinction is made between a dilution "factor" and a "ratio". A dilution "factor" is a comparison of receiving water volume plus discharge volume to the discharge volume, which is the inverse of the volumetric fraction of the discharge volume. A dilution "ratio" is the comparison of the receiving water volume to the discharge volume and is always less than the dilution "factor" by one. The dilution "factor" will be utilized throughout this initial dilution modeling since the EPA-approved hydrodynamic computer models express mixing in these terms.

Nearfield Mixing

The nearfield mixing contains two types of flow zones: the zone of flow establishment and the zone of established flow. In the zone of flow establishment, the core of the discharge plume remains relatively undiluted. The plume's momentum is decreased, progressively from the edge to the core, by shear effects with the slower-moving receiving water. When the shear effects reach the core of the discharge plume, the centerline of the discharge plume becomes diluted. The zone of flow establishment extends from the port orifice up to a maximum of six plume diameters downstream. The receiving water crossflow can also serve to speed up the mixing process in the zone of flow establishment.

In the zone of established flow, the center of the discharge plume has been affected by turbulent shear with the receiving water. The zone of established flow probably does not occur for very long since the receiving water crossflows quickly change the direction and profile of the discharge plume.

Farfield Mixing

The farfield mixing occurs after the initial velocity of the discharge plume has dissipated. The discharge plume then further mixes into the receiving water due to turbulence.

Models

The two EPA-approved hydrodynamic models used to assess dilution factors are PLUMES for the discharge into Lake Washington and RIVPLUME for the discharge into the Sammamish River. Model input parameters included the following:

- Discharge flow and temperature
- Lake current speeds and temperatures
- River geometry and velocity
- Discharge port geometry and depth.

Results

From 173-201A WAC, mixing zone boundary requirements fall into two categories: chronic and acute. Chronic mixing zone boundary requirements are: (1) not to extend in a downstream direction for a distance from the discharge port(s) greater than 300 feet plus the depth of water over the discharge port(s); (2) not to utilize greater than 25 percent of the flow; or (3) not to occupy greater than 25 percent of the width of the river.

Acute mixing zone boundary requirements are: (1) not to extend beyond 10 percent of the distance towards the downstream boundary of the chronic mixing zone; (2) not to utilize greater than 2.5 percent of the flow; or (3) not to occupy greater than 25 percent of the width of the river. The boundary requirements of the mixing zone with two feet of water over the twin 72-inch diameter outfalls are listed in Table 13.

Table 13. Boundary Requirements in Sammamish River

Parameter	Value
Acute distance	30.2 feet
Chronic distance	302.0 feet
2.5 percent of flow	45.2 mgd
25 percent of flow	452.4 mgd
25 percent of river width	45 feet

The mathematical model dilution factors for discharge at the acute and chronic boundaries were estimated at 2.0:1 and 7.9:1, respectively (see Attachment B for the model outputs). The maximum theoretical dilution factor that could have occurred is 10.7:1; however, this assumes complete mixing occurs within the water column and across the river. Complete mixing is estimated to take place approximately 3,800 feet downstream, in Lake Washington.

For a dilution factor of 2.0:1 at the acute boundary, approximately 9.4 percent of the river is used. For a dilution factor of 7.9:1 at the chronic boundary, approximately 64.8 percent of the river is used. Therefore, the percent-of-river-used requirement governs and the dilution factors at the acute and chronic boundary are estimated at 1.3:1 and 3.7:1, respectively.

Analysis

The following formula shows the relationship between dilution factor, SSO discharge characteristics, receiving water characteristics, and water quality characteristics:

$$DF = \frac{(CE - CA)}{(WQS - CA)}$$

where:

DF	=	dilution factor (dimensionless)
CE	=	concentration within SSO discharge (mg/L)
CA	=	concentration within receiving water (mg/L)
WQS	=	water quality standard (mg/L)

Table 14 provides data from 173-201A WAC for the Sammamish River water quality standards, based upon a hardness of 62.8 mg/L as $CaCO_3$ and a pH of 7.2. There was no wastewater data for arsenic or selenium, so no quantitative values were provided in Table 10 or Table 12 for comparison. However, water quality standards for both contaminants must be complied with at the edge of the farfield mixing zone.

The analysis showed that ammonia (acute and chronic), copper (acute), lead (chronic), mercury (chronic) and turbidity (acute and chronic) did not comply with water quality standards at the edge of the farfield mixing zone. To comply with the water quality standards, the dilution factor would have to be increased from 1.3:1 (acute) and 3.7:1 (chronic) as follows:

- Ammonia – 350 – 4,000:1 (winter) and 150 – 2,800:1 (summer)
- Copper – 2.3:1
- Lead – 5.9:1
- Mercury – 59:1
- Turbidity – 12:1

Table 14. Sammamish River Water Quality Standards

Parameter	Acute Water Quality Standard[1] (mg/L)	Chronic Water Quality Standard[1] (mg/L)
Fecal coliform	[2]	[2]
Dissolved oxygen	[3]	[3]
Temperature	[4]	[4]
pH	[4]	[4]
Turbidity	[5]	[5]
Ammonia[6] at 41.7 °F	0.045829	0.003960
Ammonia[6] at 69.5 °F	0.125731	0.006778
Arsenic[7]	0.360000	0.190000
Cadmium[7]	0.002236	0.000731
Chromium[8]	0.015000	0.010000
Copper[7]	0.010977	0.007628
Lead[7]	0.038781	0.001511
Mercury[9]	0.002100	0.000012
Nickel[7]	0.954894	0.106049
Selenium[7]	0.020000	0.005000
Silver[7]	0.001550	-
Zinc[7]	0.077164	0.070463

Notes:

[1] from 173-201A WAC using a hardness of 62.8 mg/L as CaCO3.

[2] Does not exceed a geometric mean value of 50 colonies/100 mL and does not have more than 10% of all samples obtained for calculating the geometric mean value exceeding 100 colonies/100 mL.

[3] No measurable decrease from natural conditions.

[4] No measurable change from natural conditions.

[5] Shall not exceed 5 NTU over background conditions.

[6] Un-ionized NH_3; Temperature Range 41.7 - 69.5 °F; pH = 7.2; Salmonids Present

[7] Dissolved portion of the heavy metal.

[8] Recoverable portion of heavy metal.

[9] Acute is dissolved portion of heavy metal; Chronic is recoverable portion of heavy metal.

Discharge Characterization Summary

Discharge of the modeled 170 mgd flow for a period of six hours (42.5 MG) into Sammamish River would be through dual 72-inch diameter pipes adjacent to the 68th Avenue Bridge. From the computer modeling, the complete mixing zone of a potential discharge would extend across the width and depth of the river, exceeding the new mixing zone boundary requirements, and would extend approximately 3,800 feet downstream into Lake Washington. The modeling showed the river would provide acute and chronic dilution factors of 1.3:1 and 3.7:1, respectively. From these, the levels of ammonia (acute and chronic), copper (acute), lead (chronic), mercury (chronic), and turbidity (acute and chronic) would exceed water quality standards at the edge of the mixing zone.

Conclusions

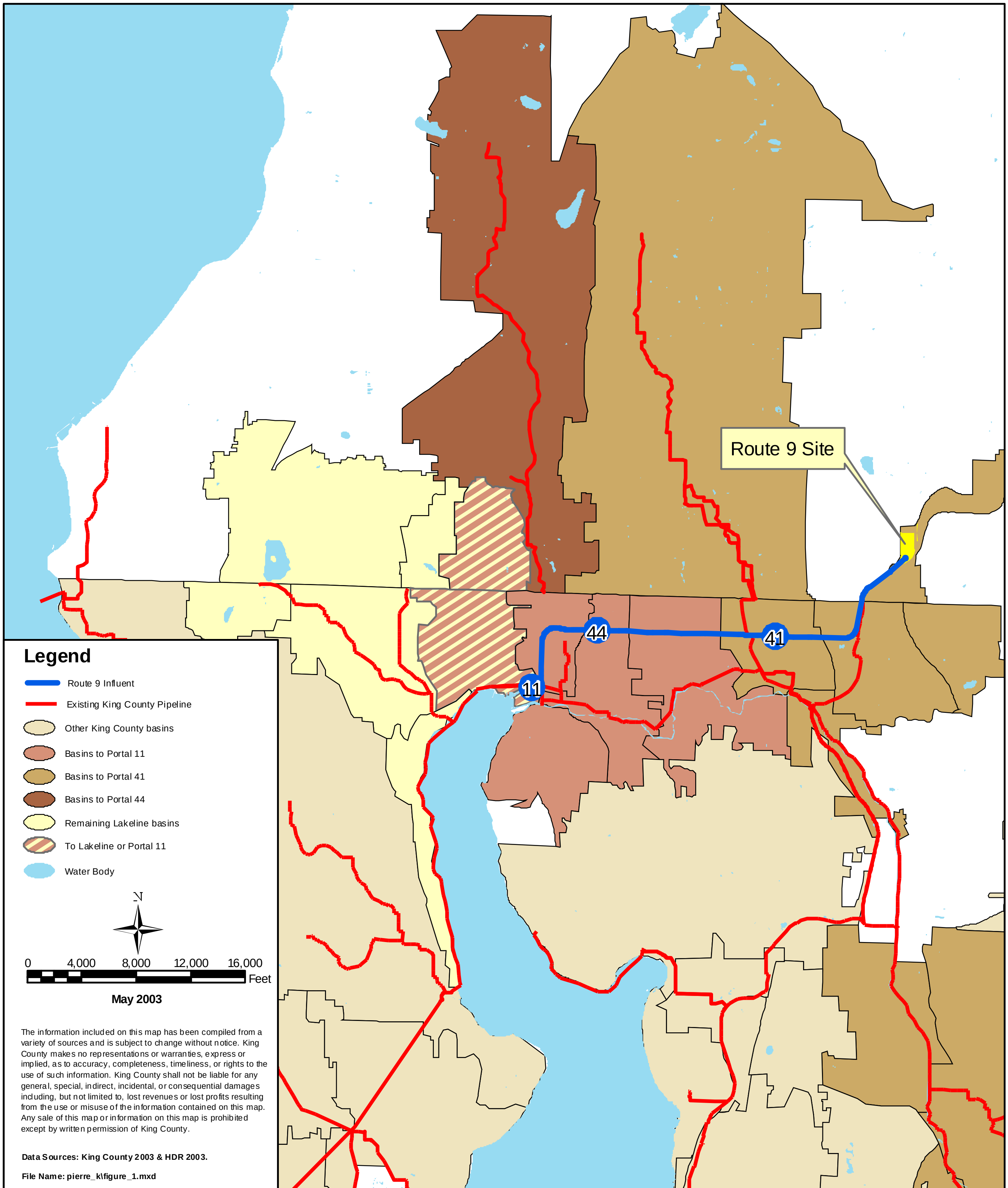
The proposed Brightwater System would be constructed to provide a higher standard of reliability than what currently exists in the conveyance system. The increased reliability is due to multiple additional mechanical and electrical redundancies at the pump stations as well as the inclusion of additional storage volume in the new influent tunnel. In the event of a series of mechanical and power failures, the new and existing conveyance system facilities would have the capacity to provide a minimum of six hours of storage during peak flow conditions for operators to restore the Brightwater System to operation. The use of flow diversions to King County's other two wastewater treatment plants, West Point and South, or potentially to the City of Edmonds wastewater treatment plant would provide reduced flows to the treatment plant and correspondingly increase the time that the system could be restored to service.

An SSO would occur if after six hours, the Brightwater System is still not operational and all available storage is filled. Assuming a constant Phase II peak flow of 170 mgd, the probability of such an occurrence due to varying combinations of mechanical and powers failures would be at most once in every 75 years if the new conveyance tunnel is sized to provide at least 11.3 MG of available storage volume. Use of flow diversions to other treatment plants, restoration of at least partial service prior to the storage filling, and increasing equipment and power reliability through proper design and operational measures would all decrease the frequency of an SSO in the Brightwater service area.

If an SSO would occur due to a very rare combination of events, then the SSO would occur for the Route 9 and Unocal System Alternatives at a safety relief point in the Sammamish River, immediately upstream of Lake Washington. The purpose of the safety relief point would be to greatly reduce the potential of environmental impacts of an SSO by moving the location of the SSO from nearby local collection systems into the Sammamish River, which would provide a large body of water for dilution purposes. An SSO would still exceed multiple water quality standards, which is the reason why the proposed Brightwater System has provided a greater level of reliability than currently exists in the other portions of the existing conveyance system.

References

Garry Struthers Associates, Inc. 1998. *Predesign Report for the Kenmore Pump Station Emergency Bypass*.



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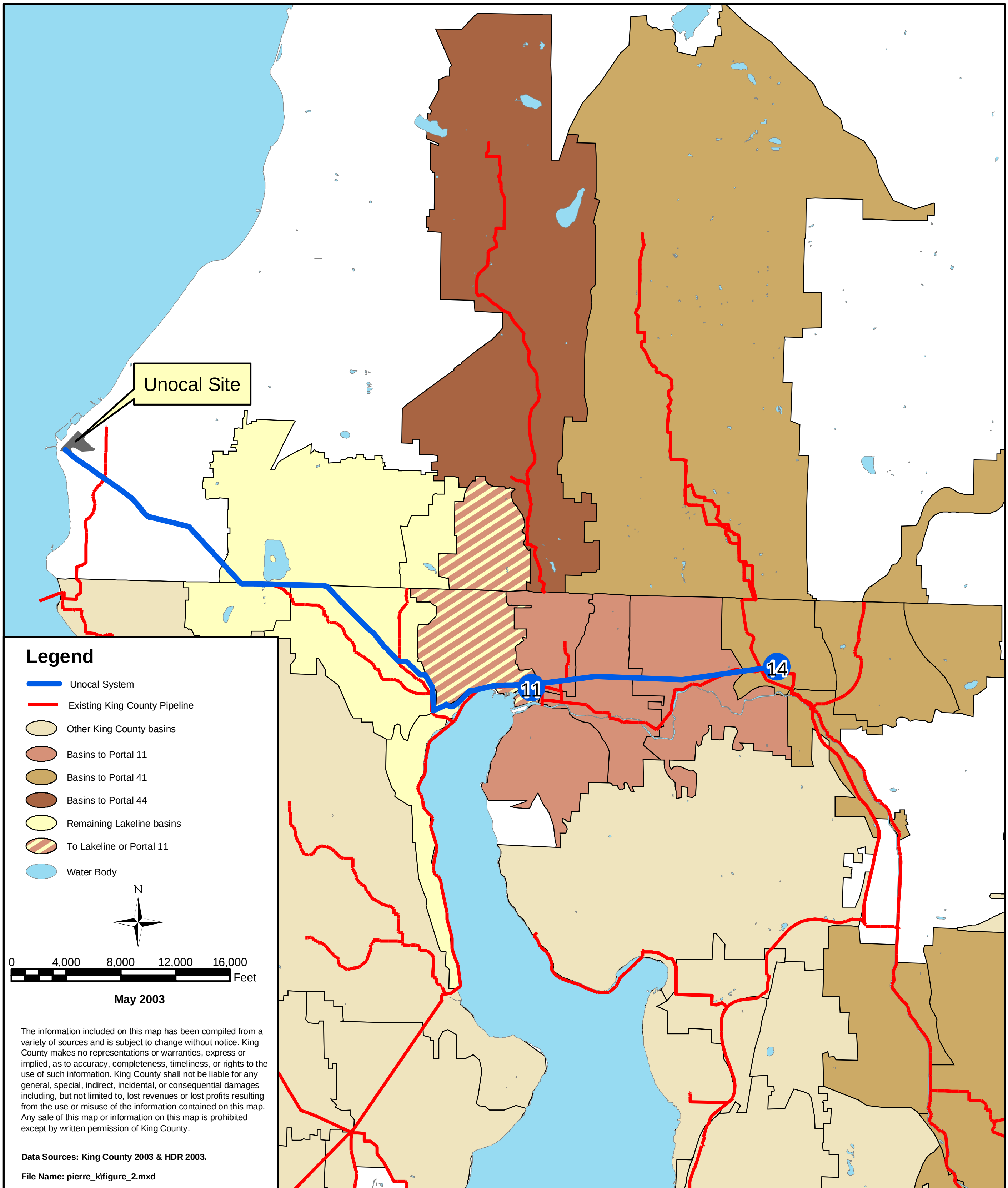
Note: King County is proceeding with preliminary plans and designs for the Brightwater proposal. This ongoing preliminary work will not limit the choice of reasonable alternatives to be selected at the end of the EIS process.

Figure 1
Route 9 Basin Flows
BRIGHTWATER TREATMENT SYSTEM



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Data Sources: King County 2003 & HDR 2003.

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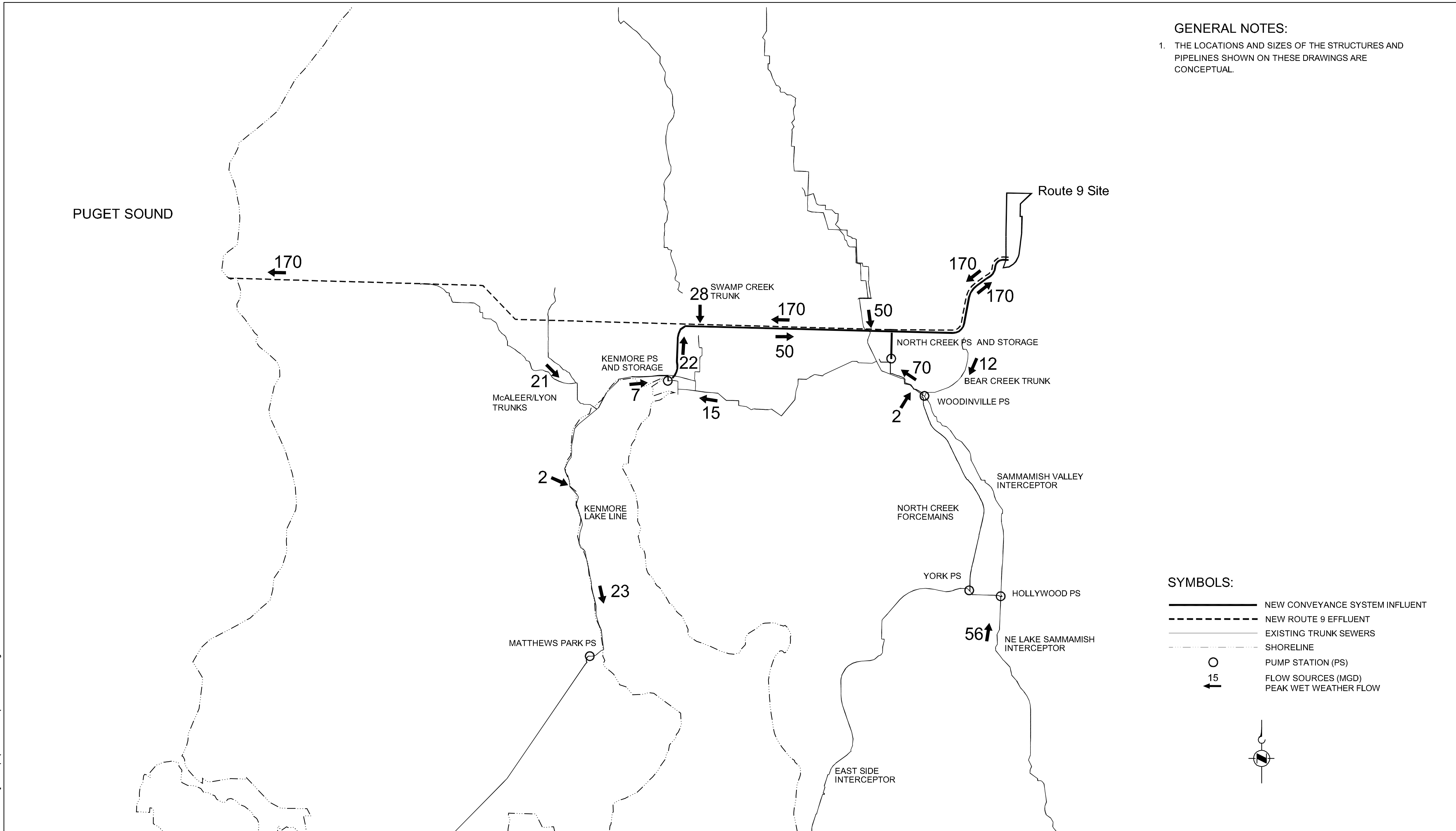
Note: King County is proceeding with preliminary plans and designs for the Brightwater proposal. This ongoing preliminary work will not limit the choice of reasonable alternatives to be selected at the end of the EIS process.

Figure 2
Unocal Basin Flows
BRIGHTWATER TREATMENT SYSTEM



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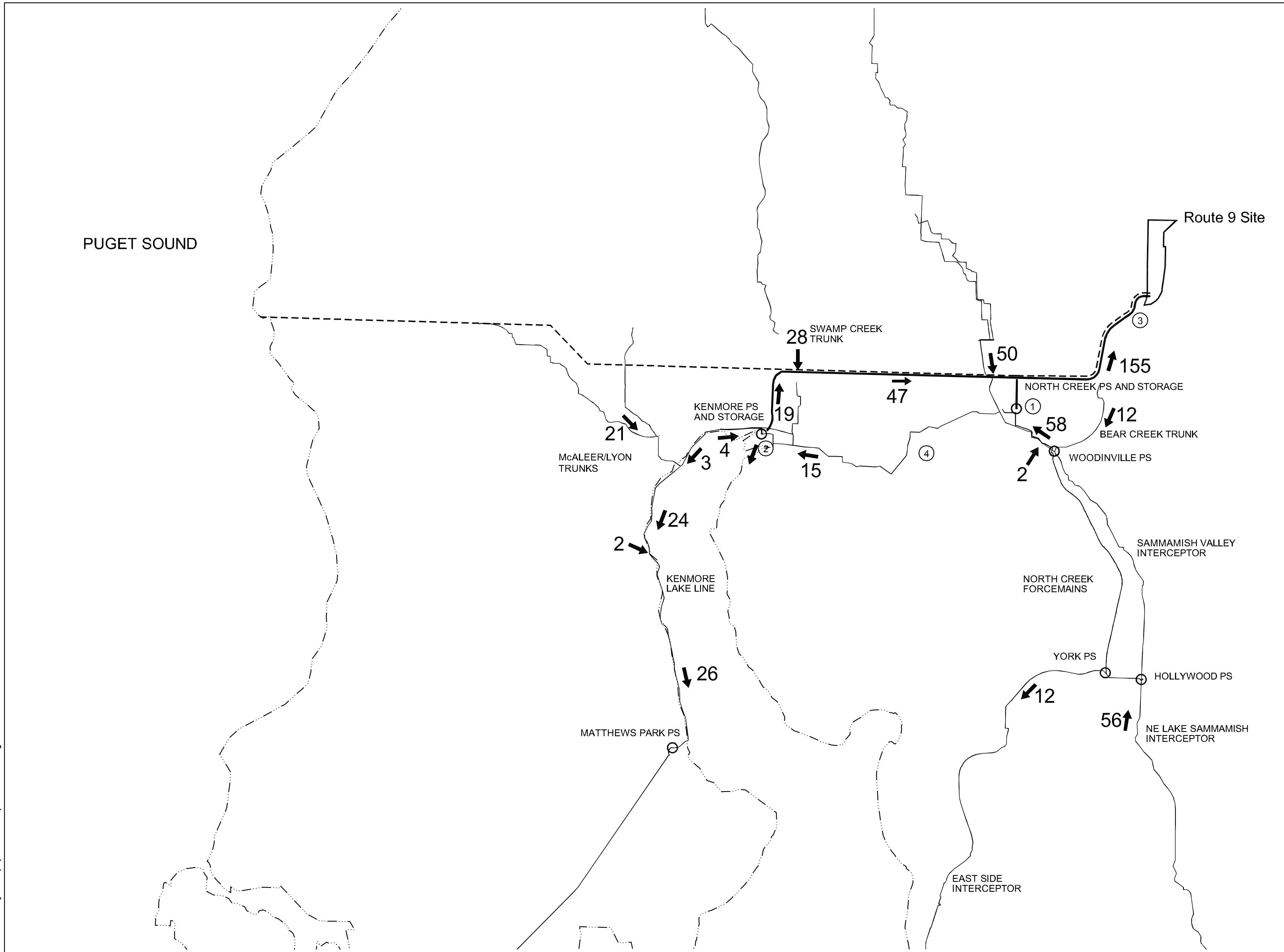
Wastewater Treatment Division

Data sources:

File name:

Figure 3
NORMAL CONVEYANCE (170 MGD)
BRIGHTWATER ROUTE 9 SYSTEM



GENERAL NOTES:

1. THE LOCATIONS AND SIZES OF THE STRUCTURES AND PIPELINES SHOWN ON THESE DRAWINGS ARE CONCEPTUAL.

KEY NOTES:

1 DIVERT TO 6 MG NORTH CREEK STORAGE.

2 DIVERT TO 4 MG LOGBOOM STORAGE.

3 AVAILABLE STORAGE IN INFLUENT TUNNEL IS ~11 MG.

4 SURCHARGE BOTHELL - WOODINVILLE INTERCEPTOR FOR 2 MG OF STORAGE.

SYMBOLS:

NEW CONVEYANCE SYSTEM INFLUENT
NEW ROUTE 9 EFFLUENT
EXISTING TRUNK SEWERS
SHORELINE
PUMP STATION (PS)
15 FLOW SOURCES (MGD) PEAK WET WEATHER FLOW

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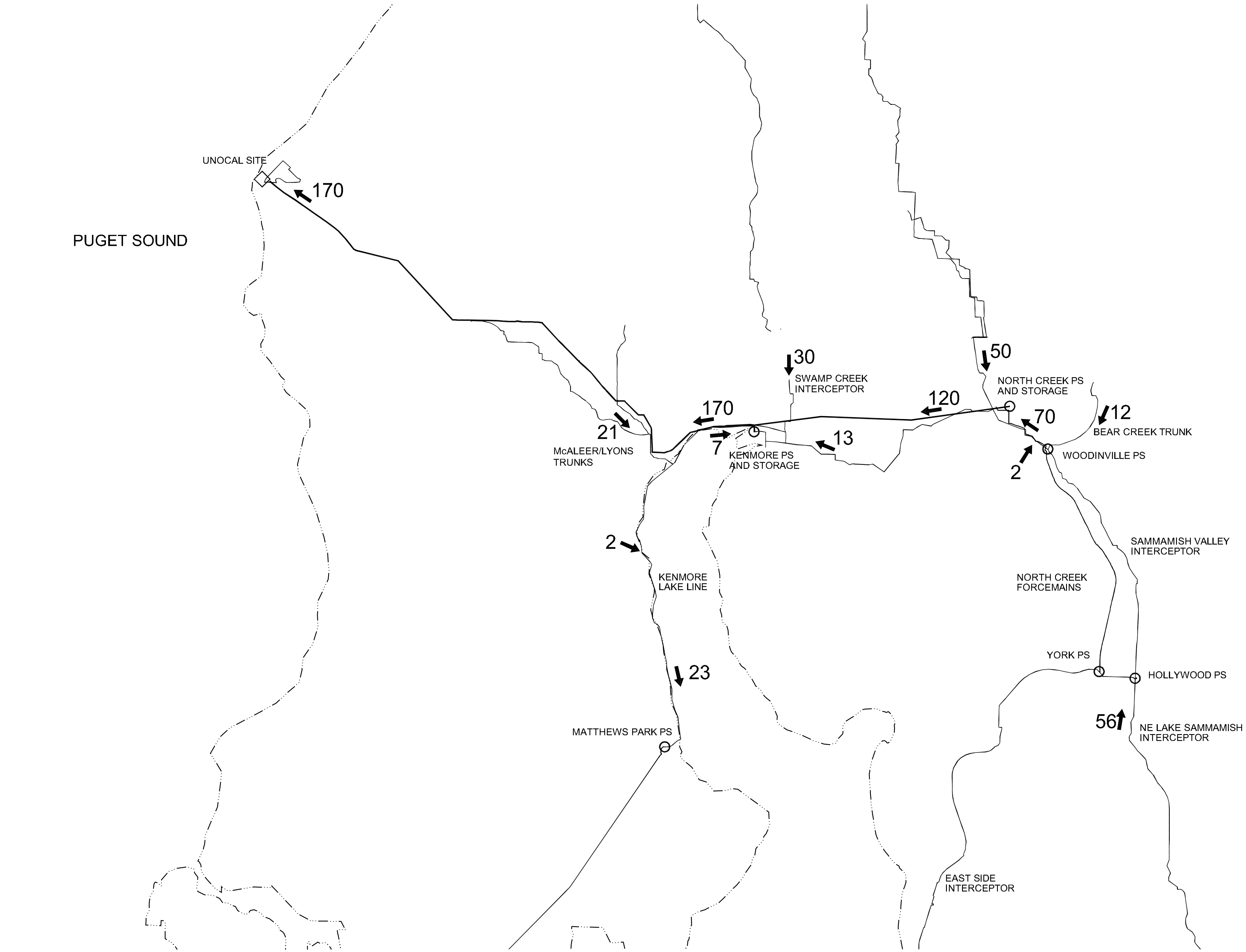
King County
Department of
Natural Resources and Parks
Wastewater Treatment
Division

Data sources:

File name:

Figure 4
EMERGENCY CONVEYANCE (170 MGD)
BRIGHTWATER ROUTE 9 SYSTEM



GENERAL NOTES:

1. THE LOCATIONS AND SIZES OF THE STRUCTURES AND PIPELINES SHOWN ON THESE DRAWINGS ARE CONCEPTUAL.

SYMBOLS:

NEW CONVEYANCE SYSTEM INFLUENT
NEW ROUTE 9 EFFLUENT
EXISTING TRUNK SEWERS
SHORELINE
PUMP STATION (PS)
15 FLOW SOURCES (MGD)
PEAK WET WEATHER FLOW

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Division

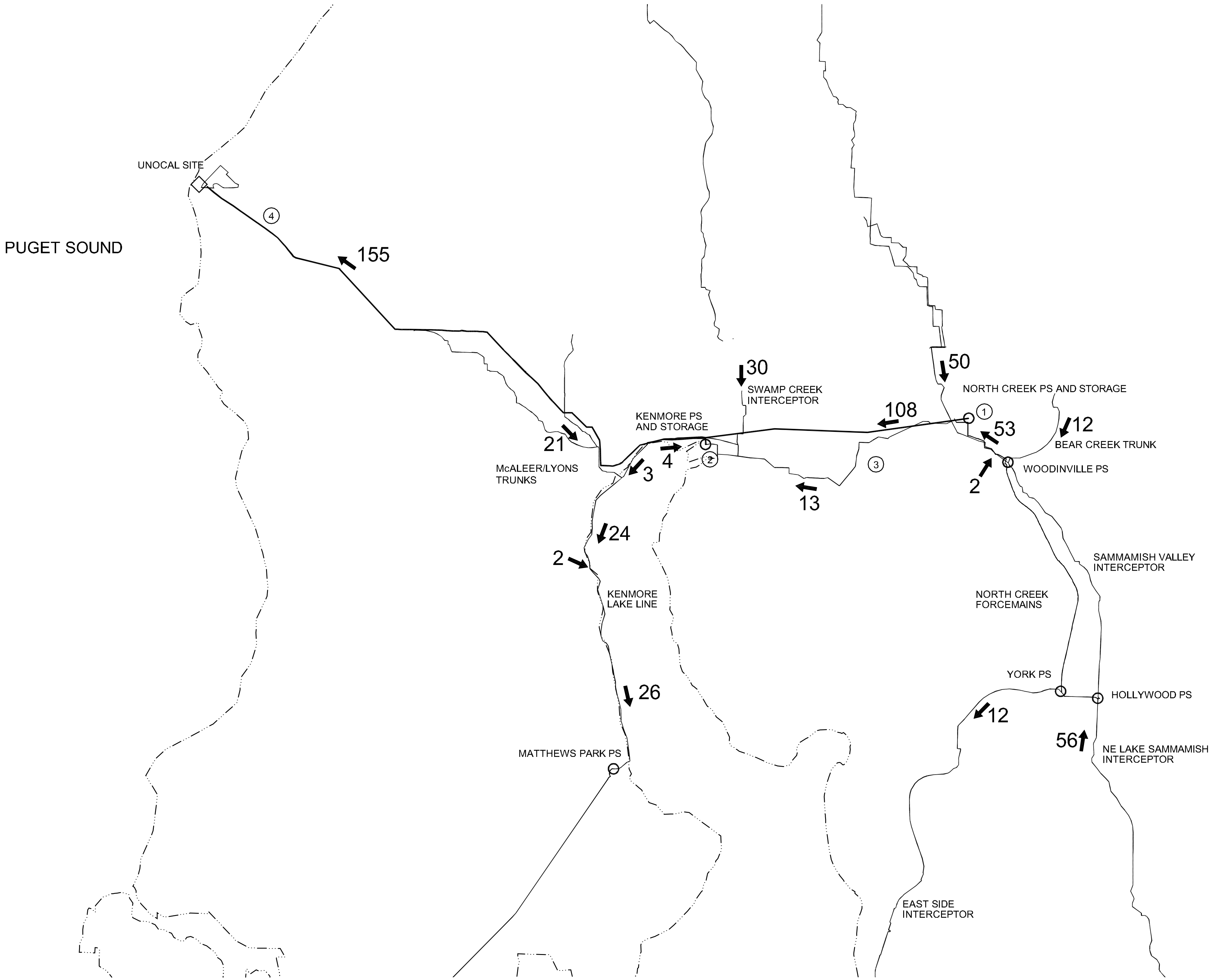
Data sources:

File name:

Figure 5

NORMAL CONVEYANCE (170 MGD)

BRIGHTWATER UNOCAL SYSTEM



GENERAL NOTES:

1. THE LOCATIONS AND SIZES OF THE STRUCTURES AND PIPELINES SHOWN ON THESE DRAWINGS ARE CONCEPTUAL.

KEY NOTES:

1. DIVERT TO 6 MG NORTH CREEK STORAGE.
2. DIVERT TO 4 MG LOGBOOM STORAGE.
3. SURCHARGE BOTHELL - WOODINVILLE INTERCEPTOR FOR 2 MG OF STORAGE.
4. AVAILABLE STORAGE IN INFLUENT TUNNEL IS ~12 MG.

SYMBOLS:

NEW CONVEYANCE SYSTEM INFLUENT
NEW ROUTE 9 EFFLUENT
EXISTING TRUNK SEWERS
SHORELINE
PUMP STATION (PS)
15 FLOW SOURCES (MGD) PEAK WET WEATHER FLOW

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Wastewater Treatment
Division

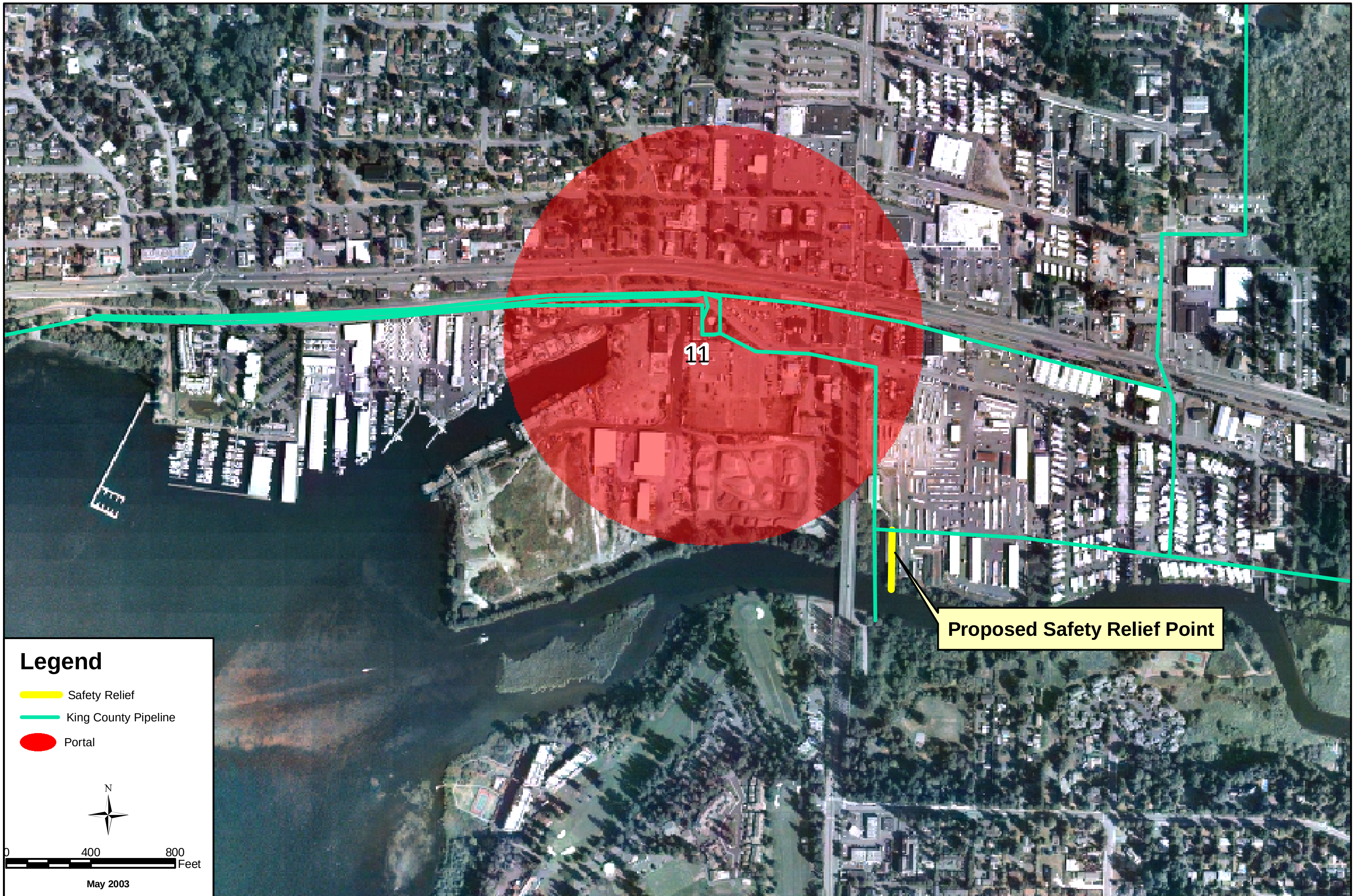
Data sources:

File name:

Figure 6

EMERGENCY CONVEYANCE (170 MGD)

BRIGHTWATER UNOCAL SYSTEM



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Note: King County is proceeding with preliminary plans and designs for the Brightwater proposal. This ongoing preliminary work will not limit the choice of reasonable alternatives to be selected at the end of the EIS process.

Figure 7

Safety Relief

BRIGHTWATER TREATMENT SYSTEM

Attachment A

Tunnel Storage Calculations

Job No. 00019.460002 No. Tsk 51

HDR Computation

HDR

Project	KCWTD - Brightwater Conveyance	Computed PK	Date 030511
Subject	Safety Relief Discharge Analysis	Checked PK	Date 030530
Task	Storage Volume Required	Sheet 1	Of 1

Assumptions

1. 6 hrs of storage required
2. Peak hour flow constant for entire 6 hours

156 mgd Q_{IN}, 75-yr power/flow
− 70 mgd $Q_{\text{influent PS}}$
86 mgd
− 34 mgd Q_{max} to North Creek Storage → (A)
52 mgd
− 36 mgd Q_{max} to Logboom Storage and Bothell-Woodinville Interceptor → (B)
16 mgd to influent tunnel

(A) $\frac{6.0\ MG}{34\ mgd} \cdot \frac{24\ hrs}{d} = 4.2$ hours

(B) $\frac{6.0\ MG}{36\ mgd} \cdot \frac{24\ hrs}{d} = 4.0$ hours

min 4.0 hours

Storage Volume Required in Influent Tunnel:

$(4\ hrs) \cdot 16\ mgd \cdot \frac{d}{24\ hrs} + (6-4\ hrs) \cdot 86\ mgd \cdot \frac{d}{24\ hrs} + 1.5\ MG$ due to poor power

$= \boxed{11.3\ MG}$

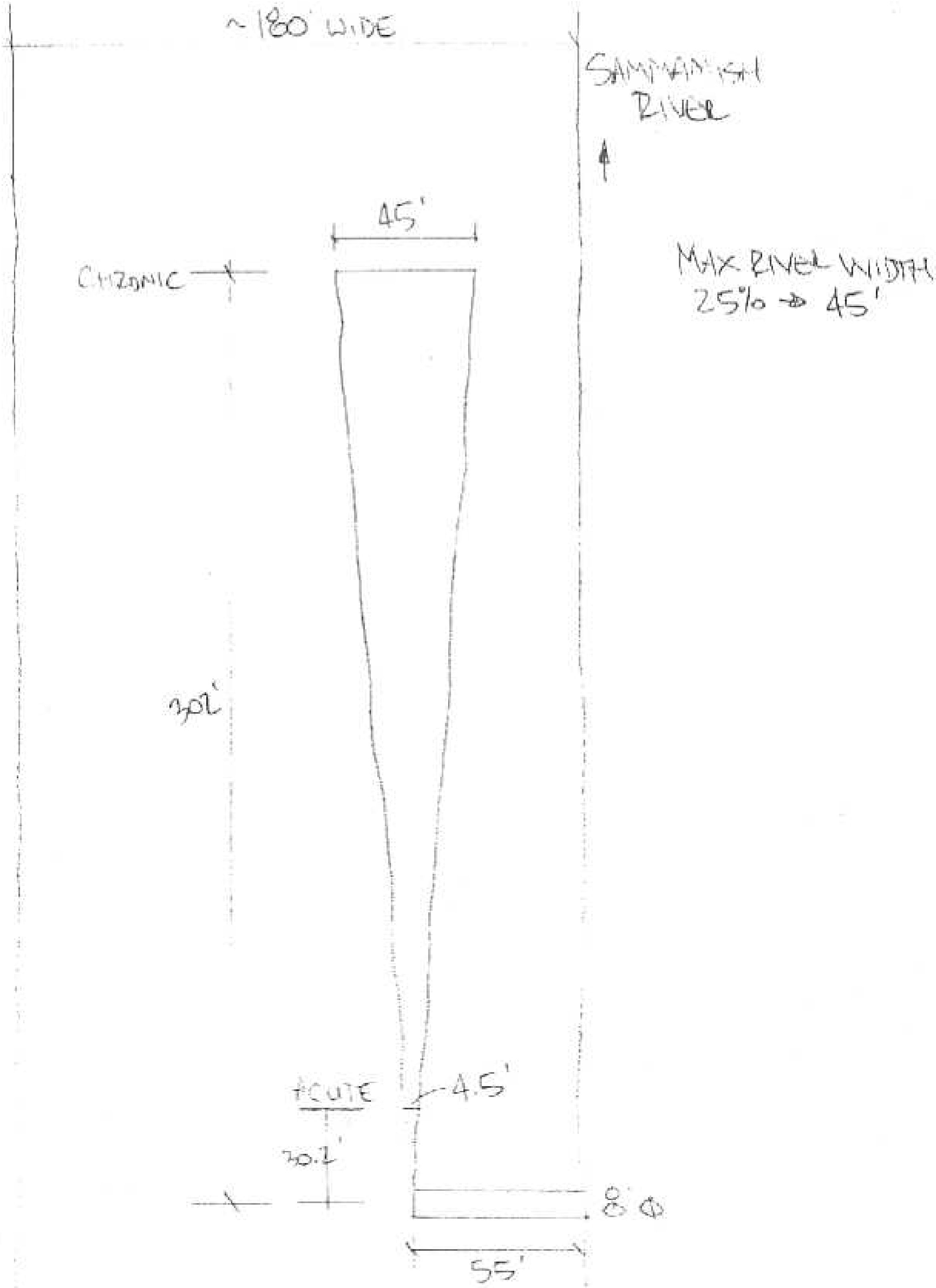
Attachment B

Sammamish River Model Outputs

Job No. | No.

HDR Computation

Project	Computed	Date
Subject	Checked	Date
Task	Sheet	Of



King County Emergency Flow Management - Sammamish River Outfall at 68th
Spread of Point Discharge in River with and without Boundary Effect from Shoreline

Effluent Discharge Rate (CFS) *INPUT*			263.03
Ambient Stream Depth at Discharge (FT) *INPUT*			10
Ambient Stream Velocity at Discharge (FPS) *INPUT*			2.08
Ambient Stream Width at Discharge (FT) *INPUT*			180
Ambient Stream Slope (FT/FT) *INPUT*			0.00100
Effluent Discharge Distance from Nearest Shoreline (FT) *INPUT*			55
Distance Downstream from Discharge to Point of Interest (FT) *INPUT*			30.2
Distance from Nearest Shoreline to Point of Interest (FT) *INPUT*			57.25
Concentration of Conservative Substance (%) *INPUT*			100
Source Conservative Mass Input Rate (Discharge Rate x %)			26303
Shear Velocity (FPS)			0.57
Transverse Mixing Coefficient (FT^2/SEC)			3.40
Plume Characteristics Assuming No Shoreline Effect			
Unbounded Plume Width at Point of Interest (FT)			39.77
Concentration at Point of Interest (Equation 5.7)			50.74
Plume Characteristics Assuming Shoreline Effect			
Co			7.0254
x'			0.0015
y'o			0.3056
y' at Point of Interest			0.3181
Term for n =	-2	*INPUT*	0.0000
Term for n =	-1	*INPUT*	0.0000
Term for n =	0	*INPUT*	0.9747
Term for n =	1	*INPUT*	0.0000
Term for n =	2	*INPUT*	0.0000
C/Co			7.04
Concentration at Point of Interest (Equation 5.9)			49.45
Approximate Downstream Distance to Complete Mixing (FT)			3,818
Theoretical Dilution Factor at Complete Mixing			14
Calculated Dilution Factor at Point of Interest			2.0

King County Emergency Flow Management - Sammamish River Outfall at 68th
Spread of Point Discharge in River with and without Boundary Effect from Shoreline

Effluent Discharge Rate (CFS) *INPUT*			263.03
Ambient Stream Depth at Discharge (FT) *INPUT*			10
Ambient Stream Velocity at Discharge (FPS) *INPUT*			2.08
Ambient Stream Width at Discharge (FT) *INPUT*			180
Ambient Stream Slope (FT/FT) *INPUT*			0.00100
Effluent Discharge Distance from Nearest Shoreline (FT) *INPUT*			55
Distance Downstream from Discharge to Point of Interest (FT) *INPUT*			30.2
Distance from Nearest Shoreline to Point of Interest (FT) *INPUT*			52.75
Concentration of Conservative Substance (%) *INPUT*			100
Source Conservative Mass Input Rate (Discharge Rate x %)			26303
Shear Velocity (FPS)			0.57
Transverse Mixing Coefficient (FT^2/SEC)			3.40
Plume Characteristics Assuming No Shoreline Effect			
Unbounded Plume Width at Point of Interest (FT)			39.77
Concentration at Point of Interest (Equation 5.7)			50.74
Plume Characteristics Assuming Shoreline Effect			
Co			7.0254
x'			0.0015
y'o			0.3056
y' at Point of Interest			0.2931
Term for n =	-2	*INPUT*	0.0000
Term for n =	-1	*INPUT*	0.0000
Term for n =	0	*INPUT*	0.9747
Term for n =	1	*INPUT*	0.0000
Term for n =	2	*INPUT*	0.0000
C/Co			7.04
Concentration at Point of Interest (Equation 5.9)			49.45
Approximate Downstream Distance to Complete Mixing (FT)			3,818
Theoretical Dilution Factor at Complete Mixing			14
Calculated Dilution Factor at Point of Interest			2.0

King County Emergency Flow Management - Sammamish River Outfall at 68th
Spread of Point Discharge in River with and without Boundary Effect from Shoreline

Effluent Discharge Rate (CFS) *INPUT*			263.03
Ambient Stream Depth at Discharge (FT) *INPUT*			10
Ambient Stream Velocity at Discharge (FPS) *INPUT*			2.08
Ambient Stream Width at Discharge (FT) *INPUT*			180
Ambient Stream Slope (FT/FT) *INPUT*			0.00100
Effluent Discharge Distance from Nearest Shoreline (FT) *INPUT*			55
Distance Downstream from Discharge to Point of Interest (FT) *INPUT*			302.0
Distance from Nearest Shoreline to Point of Interest (FT) *INPUT*			77.5
Concentration of Conservative Substance (%) *INPUT*			100
Source Conservative Mass Input Rate (Discharge Rate x %)			26303
Shear Velocity (FPS)			0.57
Transverse Mixing Coefficient (FT^2/SEC)			3.40
Plume Characteristics Assuming No Shoreline Effect			
Unbounded Plume Width at Point of Interest (FT)			125.77
Concentration at Point of Interest (Equation 5.7)			16.04
Plume Characteristics Assuming Shoreline Effect			
Co			7.0254
x'			0.0153
y'o			0.3056
y' at Point of Interest			0.4306
Term for n =	-2	*INPUT*	0.0000
Term for n =	-1	*INPUT*	0.0000
Term for n =	0	*INPUT*	0.7743
Term for n =	1	*INPUT*	0.0000
Term for n =	2	*INPUT*	0.0000
C/Co			1.77
Concentration at Point of Interest (Equation 5.9)			12.42
Approximate Downstream Distance to Complete Mixing (FT)			3,818
Theoretical Dilution Factor at Complete Mixing			14
Calculated Dilution Factor at Point of Interest			8.0

King County Emergency Flow Management - Sammamish River Outfall at 68th
Spread of Point Discharge in River with and without Boundary Effect from Shoreline

Effluent Discharge Rate (CFS) *INPUT*			263.03
Ambient Stream Depth at Discharge (FT) *INPUT*			10
Ambient Stream Velocity at Discharge (FPS) *INPUT*			2.08
Ambient Stream Width at Discharge (FT) *INPUT*			180
Ambient Stream Slope (FT/FT) *INPUT*			0.00100
Effluent Discharge Distance from Nearest Shoreline (FT) *INPUT*			55
Distance Downstream from Discharge to Point of Interest (FT) *INPUT*			302.0
Distance from Nearest Shoreline to Point of Interest (FT) *INPUT*			32.5
Concentration of Conservative Substance (%) *INPUT*			100
Source Conservative Mass Input Rate (Discharge Rate x %)			26303
Shear Velocity (FPS)			0.57
Transverse Mixing Coefficient (FT^2/SEC)			3.40
Plume Characteristics Assuming No Shoreline Effect			
Unbounded Plume Width at Point of Interest (FT)			125.77
Concentration at Point of Interest (Equation 5.7)			16.04
Plume Characteristics Assuming Shoreline Effect			
Co			7.0254
x'			0.0153
y'o			0.3056
y' at Point of Interest			0.1806
Term for n =	-2	*INPUT*	0.0000
Term for n =	-1	*INPUT*	0.0000
Term for n =	0	*INPUT*	0.7949
Term for n =	1	*INPUT*	0.0000
Term for n =	2	*INPUT*	0.0000
C/Co			1.82
Concentration at Point of Interest (Equation 5.9)			12.75
Approximate Downstream Distance to Complete Mixing (FT)			3,818
Theoretical Dilution Factor at Complete Mixing			14
Calculated Dilution Factor at Point of Interest			7.8